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"THE WORLD IS ITS FIELD"

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"MADE IN GERMANY." A STUDY OF COMPETITION.

By Louis Bell, Ph.D.

Dr. Bell's article will be appreciated most by those who read in this Magazine last September his striking discussion of American manufacturing methods and their tendencies. To all, however, this more concrete presentation of the topic will carry much of interest and will offer suggestions worthy of careful examination. It is an important contribution to a problem which is likely soon to become acute throughout the world—the problem of competition, in home and foreign markets, between great manufacturing nations under differing economic policies and industrial systems. Dr. Bell, though an American of the Americans, treats it from an impartial viewpoint and with admirable breadth of vision.—THE EDITORS.

IN a previous paper the writer drew attention to some inherent faults in the "American method" of manufacture. The effects of these faults, and of the causes which have produced them, upon the distribution of world trade have become worthy of serious consideration by economists. At the present time the United States stands with a tremendous balance of trade to its credit. There is happily continued prosperity, and industry is active. If, however, one studies carefully the official returns of imports and exports the fact is evident that in the last analysis Americans are chiefly purveyors of raw material and food-stuffs, together with some important natural products in more or less complete conditions of manufacture. Of strictly manufactured articles there is of course a vast and varied assortment, but it is rather more remarkable for what it omits than for what it contains, particularly if one eliminates the Canadian trade. In a sense we are a great manufacturing country, for the native market is immense, yet it is rather curious that we should import many things which we do, considering the activity of the American

manufacturer. "Made in Germany," or France, or England, is a label the frequency of which deserves some investigation.

Why, for example, should we have imported last year, against heavy duties, some $69,000,000 of manufactures of cotton? Certainly the American cotton manufacturer is not lacking in skill or foresight, yet despite the fact that we export the bulk of the world's raw cotton the balance of trade is always very heavily against us in the finished product. The imports of china, earthenware, glass, and glassware nominally run up to $20,000,000 or thereabouts, against exports almost negligible; and yet it is quite certain that native American skill can and occasionally does produce porcelain and glass of the very finest quality. The Trenton potteries, for example, are potentially capable of meeting the Europeans on their own ground. We import likewise some $15,000,000 worth of woolen cloths and nearly $10,000,000 worth of gloves, all again against heavy duties. And so the list might be extended over a wide range of manufacture, including even six or seven million dollars worth of toys.

Even in watches, loudly heralded as the finest fruit of the American method, in spite of cut rates for export, the balance of trade is steadily against us. Were the United States a free-trade country we might charge up these things to foreign cheap labor, but the protective tariff is in many cases stiff enough to cover the whole actual cost of labor at American rates with a liberal margin beside. Why then does the foreign-made label continually confront one?

Even in things like machinery, to which the American methods have been assiduously applied and which we export in large amounts, it seems to be difficult or impossible to meet the market fully enough to check heavy imports against large duties. What manner of necessity was it that caused the importation last year of about $4,500,000 worth of miscellaneous machinery?

In foreign trade, in spite of many successful inroads by American manufacturers, it has proved to be difficult to hold our own even by cutting prices for export. The South American trade is steadily slipping away and that in the Far East is menaced. Of course the carrying trade has long since passed out of American hands and the flag is now seldom seen in a foreign port. This adverse fact is not sufficient, however, to account for the difficulty of successful competition in these markets. It is not a mere question of the flag over the taffrail, but of goods and of prices, of credits and of methods of sale.

It is of course a matter of comparative indifference in these busy times, with every factory behind its orders and deliveries growing

longer, whether an order in Brazil comes to the United States or goes to Germany. What, however, will be the result when home markets have grown a little more sluggish and works are operating below their normal capacity? Will not there come a time when a world market will be sadly needed and will be found well occupied by those who are now mastering it? It is such a contingency that makes one pause and consider carefully the relation of the methods and temper of American business to foreign competition at home and abroad. There may be no immediate danger of a Zollverein against American industry, yet it is absolutely certain that there will be steady and effective pressure brought to bear against the American tariff which directly or indirectly will force it downward on pain of retaliation.

When this time shall come, and it is already in sight, the "Made in Germany," or elsewhere, mark will be seen on a somewhat wider range of goods—unless the market can be held by means evidently not now applied.

As regards importations to the United States the fundamental questions are: What goods can be profitably imported against the present duties, and why are they not met by effective competition here? The answers will bring us back in part to the failings of the American method and in part to the general conditions that have grown up in intimate association with that method.

It is not an easy matter to analyze the list of imports with precision, since its classification is not adapted to minute investigation. Aside from natural products not produced in America, and some classes of manufactures which for particular rather than general reasons are especially at an advantage abroad, the manufactured imports fall rather naturally into three categories. First may be considered those goods which are practically not produced at all in the United States. Second come those which are here produced only in limited quantities and at a very high price or of dubious quality. Third, those which can be produced, and are produced, but are unable to drive out steady foreign competition by reason of quite various causes. The relations of these categories to the theory and practice of American manufacturing are somewhat intricate, but out of them can be gathered some data on the main questions at issue, and perhaps some intimation of remedies. If one were to venture upon any generalization regarding imports it would probably be to the effect that the goods brought into the country are of the very highest and the very lowest grades, the product on the one hand of the finest skilled labor

and on the other of extremely cheap labor applied to a sometimes rather crude imitation of American methods.

The first category, of goods rarely or never made in America, would be a fairly long one composed of very widely diversified items, mainly those in which manufacture depends upon great manual or technical skill. Synthetic dyestuffs, many fabrics, chronometers, and optical glass, are excellent samples of the list. With respect to the first mentioned, the United States is not absolutely without product, but there is almost complete dependence upon Germany for colors, imported to the extent of five or six million dollars annually. Organic chemistry is a branch of science peculiarly neglected in this country, where technical training has generally run to other lines for which there is greater demand. The same impulsive desire to "get there day before yesterday" which is one of the sources of our national greatness, sadly handicaps technical education. Even our institutions of learning when attacked by an itching for "productive scholarship" sometimes do queer things. The president of one well-known University used to send to his heads of departments a monthly blank to be filled out with researches published or begun and notices of public lectures given by the incumbent. One is irresistibly reminded of the fine irascible old colonel in winter camp during the Civil War, who being informed by his chaplain that a very productive "revival" was in progress in the neighboring regiment promptly called up the officer of the day and directed him to detail thirty men to be baptized immediately, allowing that he would be blankety-blanked if he would be outdone by that Nth Ohio!

In chronometers the American method seems to strike its limitation. Occasional instruments bear an American name, but even these are often imported in parts and merely assembled and engraved here. The fine care and precision required cannot be replaced by assembling machine-made parts at random and inspecting the product only by sample, even if the machine work is fully up to the high plane reached in American watch factories.

In textile manufactures it is notorious that certain classes of goods can be secured only abroad. These are perhaps most generally such as require a relatively large labor cost, either in hand work or in care of machines. The American ideal of one low-paid girl attending a group of eight or ten automatic looms does not tend to the production of the finest fabrics, and in spite of everything cheap labor will not stay cheap on American soil. The early New England mills were run by native-born operators; then came the great tide of Irish immi-

grants; then another tide of French from across the Canadian border; and now it is Armenian, Greek, Polak, Italian—anybody who will temporarily break the price of labor. When these shall have settled themselves, as they will with astonishing rapidity, to American standards of living, it will be increasingly difficult to compete with foreign goods of the higher grades. Aside from the eternal labor question there seems to be an artistic skill and refinement, a resourcefulness and an originality among the foreign textile experts and designers that it is hard to approximate here. In making "standard" goods of certain grades the American manufacturer is exceedingly skilful and successful, but importations of the present magnitude show his limitations.

To pass easily along this line into the second category one must take account again of certain grades of textiles which are successfully produced here, but in very limited amounts and at prices which can compete with imports only on a modest scale. There are certain cotton mills which turn out particular classes of semi-standard fine goods of as beautiful quality as can be obtained anywhere in the world. But they are relatively few and small, and as a rule only moderately profitable. If one hears of a mill that is paying huge dividends, that mill is more than likely to make print-cloths or similar stuffs in which profit often depends chiefly on shrewd cotton buying.

Into this second category, too, fall such diverse articles as porcelain, fine firearms, toys, and various kinds of machinery. One of the most curious phenomena in imports is the considerable amount of English textile machinery that finds its way into America. Some foreign experts boldly say that we are behind the times in such equipment and still use methods and apparatus already discarded abroad. That such a condition actually does hold with respect to certain branches of engineering is only too true, but be that as it may, for some reason or other American makers of textile machinery have never been able to hold the whole home market.

Fine firearms and toys represent industrial antipodes, the former extraordinarily expert hand work, the latter very cheap labor acting with crude but effective labor-saving methods and inspired by exceptional ingenuity. High-grade firearms are made here, but in small quantities, the chief output being in the medium grades in which costly hand work is successfully replaced by the American method. The result is a wonderful fifteen or fifty dollars' worth of weapon, not quite equal however in finish and balance to the best work of the foreign armourers, so that English and German guns and rifles are

found here in large numbers. Perhaps the existence of a well applied proof system in the former country is an element in the case.

And so the story goes on through a long line of articles which are made here only in a very limited way and are generally imported. Finally there are many grades of goods which can be and are made here for the home trade but which are supplemented by abnormally large importations. Many fabrics fall within this list, especially novelties of various sorts, together with a vast number of miscellaneous articles. The American method with its relatively standardized output and dislike of changing production is primarily responsible. But behind this lies a certain quality or shortsightedness, to which reference was made in the previous paper—a view which concerns itself only with the present fiscal year. There is the same tendency toward capitalization on an assumed maximum earning capacity in American manufacture as in American railroads, fortunately to a less degree and less generally. The desire for quick profits is of course world-wide and entirely proper, but it sometimes overreaches itself. In the long run the manufacturer who keeps in close touch with progress and is not afraid to vary his production to meet the world's needs will win out in the world's markets. He may have to content himself with less profits in some given year and reckon on squaring himself in another. A quarter-century, however, will even things up. So long as America has a rapidly expanding home market, and quantity of production is the only thing which limits profits, the present course goes on prosperously enough. It is the time of open competition with the world that will bring cause for anxiety.

In the engineering lines, for example, we are in the midst of a period of splendid prosperity. The home market keeps work going overtime, and behind orders at that. Meanwhile, outside the country, trade slips away from our disinclination to meet local conditions and methods. Even in electrical goods, of which we are large exporters, many a foreign contract goes against us to Continental makers even with difference of freight in our favor. Of course Continental labor costs in electrical works are only about half of those here, which makes competition difficult. Two other adverse factors however, are less necessary. It is difficult to get American makers to depart from their customary standards to suit foreign needs, and American capital, however bold at home, loses heart when it crosses the borders by land or sea. Valuable foreign franchises not infrequently go begging here and are promptly snapped up and made profitable by foreign capital. The same situation exists with reference to mining machinery and plants of various other kinds.

American methods in such cases suffer from their lack of flexibility. The acute desire to "standardize" everything renders us very slow to pick up manifest improvements, albeit when we do pick them up we often make better use of them than the originators. It is rather humiliating, for instance, to realize that nearly all recent improvements in electric lamps, both arc and incandescent, bear the foreign trademark, in spite of the fact that electric lighting is in the main of American origin. Similarly, in spite of all the country has done in the development of the steam engine American manufacturers are years behind the times in the use of superheated steam, likewise in the application of producer gas to serious work. There are one hundred and eighty German electric supply plants operated wholly by gas or oil engines and nearly as many more with such engines as auxiliaries.

No country can lead the world in improvements and at the same time confine itself to standard types. The present tendency here is such that the radical improvements in many lines are being made elsewhere. As a result the world markets are being won by others.

However effective our tariff may be in encouraging American manufacture in general, it is of small use in extending the foreign trade in the products of that manufacture, and every year the pressure of retaliation increases. If we ever are to regain the first place in active improvements it must be by taking advantage of prosperous times. When dull times come there will be little heart for large expenditure for experimenting along new lines. The kinds of manufacture in which America needs just now to be strengthened are the manufacture of high-grade goods now generally imported, and of goods especially suited to the needs of importing countries. The American method can take care admirably of the field it now fills, so long as foreign competitors with cheap labor do not really learn the game. The danger is that they will prove apt scholars, and by applying American labor-saving methods with the aid of labor already cheap, may gradually and steadily restrict the field in which Americans are now supreme. The remedy is not to shut one's eyes and declaim with patriotic pride of the continued prosperity of our industries, but to take up the march of improvement all along the line with something of the old swift alertness, and to prepare to meet the competition of the world in every grade of manufacture that its peoples demand.

THE SQUARE DEAL TO THE RAILROAD EMPLOYEE.

By H. W. Jacobs.

It is eight years since H. F. L. Orcutt, writing in these pages of a contrast in industrial policies at that time newly apparent, used the significant words: "It is economy as well as humanity to plan factories in which human life is of more account than machinery; into which human beings will not be driven by hunger, but attracted by superior hygienic surroundings—air, light, comfort—as well as by the most modern equipment for saving labor, increasing output, and raising the standard of workmanship and wages."

No one movement in the field of "Power and Production" during the intervening period is more striking than the progress of this concept in the belief and the practice of the foremost employers. We are glad that much of the current history of the advance has been written in THE ENGINEERING MAGAZINE. We are especially glad now to show so brilliant an example of its extension into a branch of engineering activity which sometimes has not been closely associated with the idea of care for the individual life. Mr. Jacobs' present article is a welcome demonstration that there are railway managers by whom the "square deal to the employee" is considered equal in importance to the increase of "efficiency in the railway machine shop."—THE EDITORS,

IN the September issue of THE ENGINEERING MAGAZINE, Dr. Louis Bell sounded a note of warning against the result of the American manufacturing method—devotion to securing the largest output of uniform character at minimum cost. He pointed out that this made automata out of the operatives and discouraged skilled, intelligent, and thoroughly trained artisans, to so great an extent that the quality of the men today was generally poor and unreliable.

Much of late has been written of the measures taken by manufacturing concerns to attract men of high character to their employ—to surround their men with an environment making toward integrity, sobriety, and industry, and not only to make the lot of the workmen a more agreeable one, but to reward him in proportion to his efforts as well, in order to avoid the evils of "the American tendency." Although less has been written regarding their treatment of employees, some of the railroads have been doing a work along these lines unequalled in depth of motive and breadth of application.

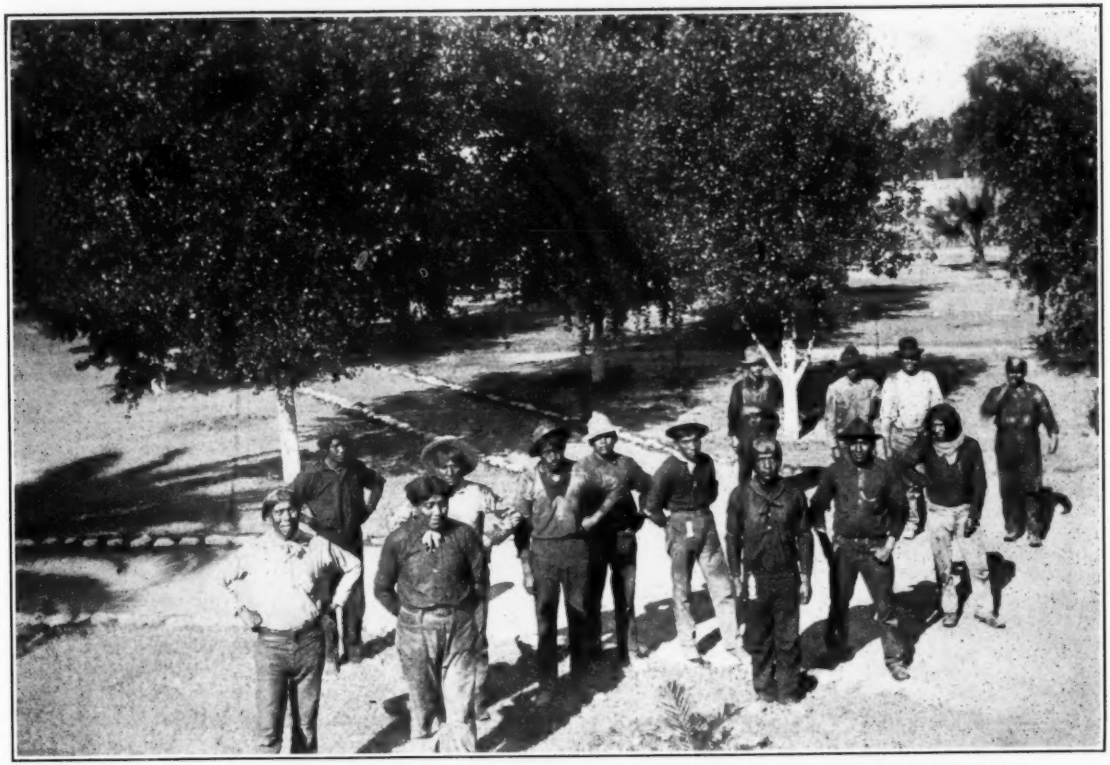
E. P. Ripley, president of the Santa Fe system is quoted in the Chicago Record-Herald of January 5, as saying:

"One of the most serious conditions which this country is facing today is the indifference and the disregard which the employee has for the interests of the employer.

"The Santa Fe," continued Mr. Ripley, "hopes to establish a bet-

EXAMPLES OF SANTA FE METHODS IN MAKING AN ATTRACTIVE ENVIRONMENT FOR THEIR EMPLOYEES.

The upper view is of the shop yards and offices at the Needles; the gold-fish basin has an umbrella cover to protect the fish from the glaring sun. The lower view is of a station park at a desert point.



A GROUP OF MOJAVE INDIANS, EMPLOYED BY THE SANTA FE AS WIPERS, SWEEPERS, AND HANDY MACHINISTS.

TYPICAL READING ROOMS, PROVIDED BY THE SANTA FE ROAD FOR EMPLOYEES.
The upper one is in Arizona, the lower at Richmond, Cal. There are others at La Junta, Col., at Raton, N. M., and elsewhere—about twenty altogether.

ter *esprit de corps* among its employees, and expects that a liberal pension system will have this tendency. We have on this system as much loyalty as most railroads enjoy, if not more, but it is not what it should be. The lack of loyalty among employees is a condition from which all corporations are now suffering, and it presents a most serious problem."

Railroads are the pioneers of civilization and commerce in America; they pierce mountains, blaze a way through the forest, and establish a highway through the arid plains and the desert regions of the south-west. They are antennae or feelers, through which human society reaches out and extends its domain over untrammeled nature.

THE NEW RECREATION HALL FOR EMPLOYEES ERECTED BY THE A. T. & S. F. RAILWAY AT THE NEEDLES, CALIFORNIA DESERT.

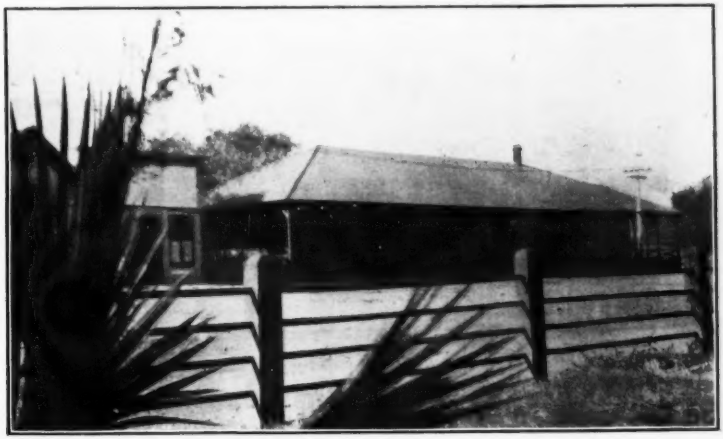
The hardy and adventurous, the bold and the wild, among our race, become prospectors, miners, ranchers or settlers, or they serve the railroad which serves all. This life, hard and rough, encourages the lawless and incubates the saloon and attendant social evils. It was hardly uncommon in a frontier town to find every third house a saloon, and to their temptations the railroader, because of his extremely unsettled and nervous life, is especially subject. For instance, in one desert town there used to arrive each month on pay-day morning, from a large Pacific Coast city about twelve-hours distant, a number of detrimentals and gamblers who spent the next few days shearing their victims.

To combat the evils of the saloon

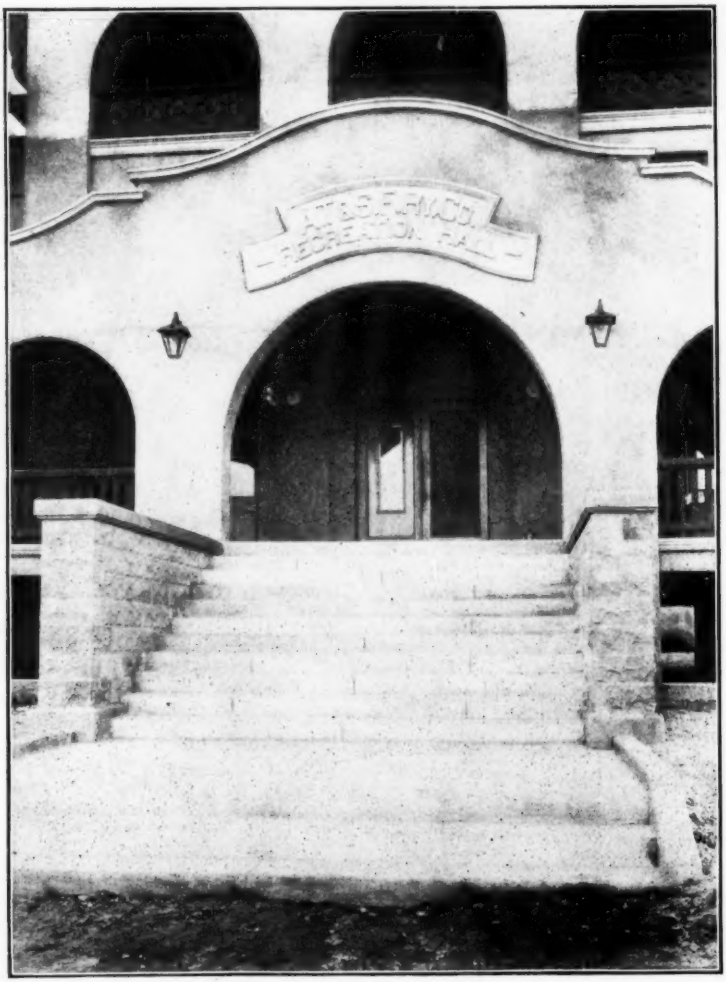
DIVISION OFFICES AT THE NEEDLES, SHOWING WIDE PORCHES AND EAVES FOR PROTECTION FROM THE DESERT HEAT.

and to encourage men of the superior class, with families or without, one Western road, the Santa Fe, has gone extensively and expensively into the construction and maintenance of reading rooms, recreation halls, hospitals and company cottages, and of parks and pleasure grounds around the stations, shops, and offices.

A station called the "Needles," on the banks of the lower Colorado river, in the heart of the Arizona-California desert (the haunt of the Mojave Indian) about one hundred miles southeast of Death Valley,



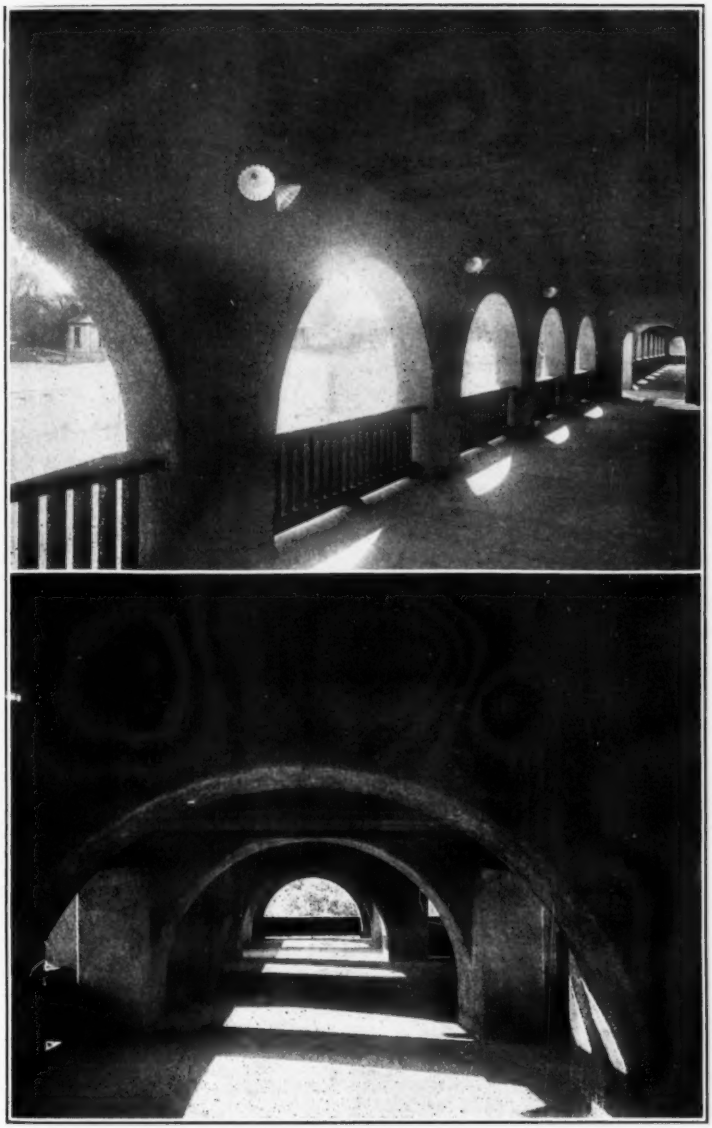
READING ROOM FORMERLY AT THE NEEDLES, CALIFORNIA.
Replaced by the fine structure shown on the page opposite and in following pictures.



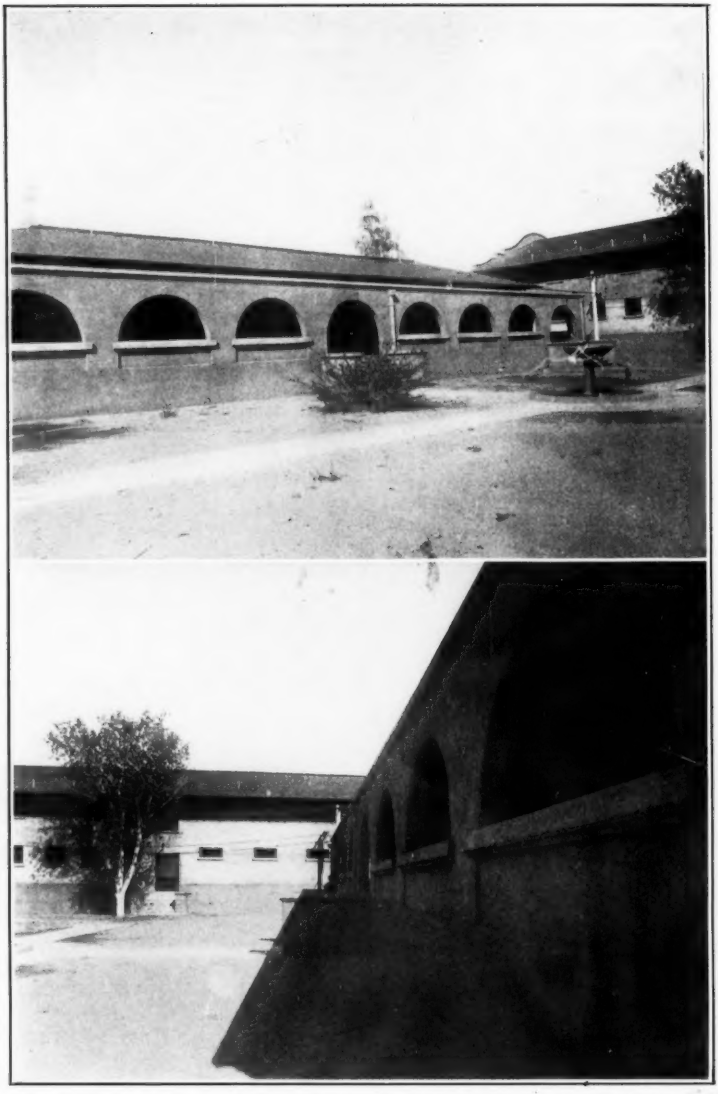
PORTAL OF THE SANTA FE RECREATION HALL AT THE NEEDLES.

being a shop and division point, was typical of severe conditions. It was said that the railroader's experience was not complete until he had spent some time there; that a machinist who could hold on for three months would be promoted to master mechanic. The summer heat is intense, yet notwithstanding these severe conditions the climate is salubrious, and in winter, ideal.

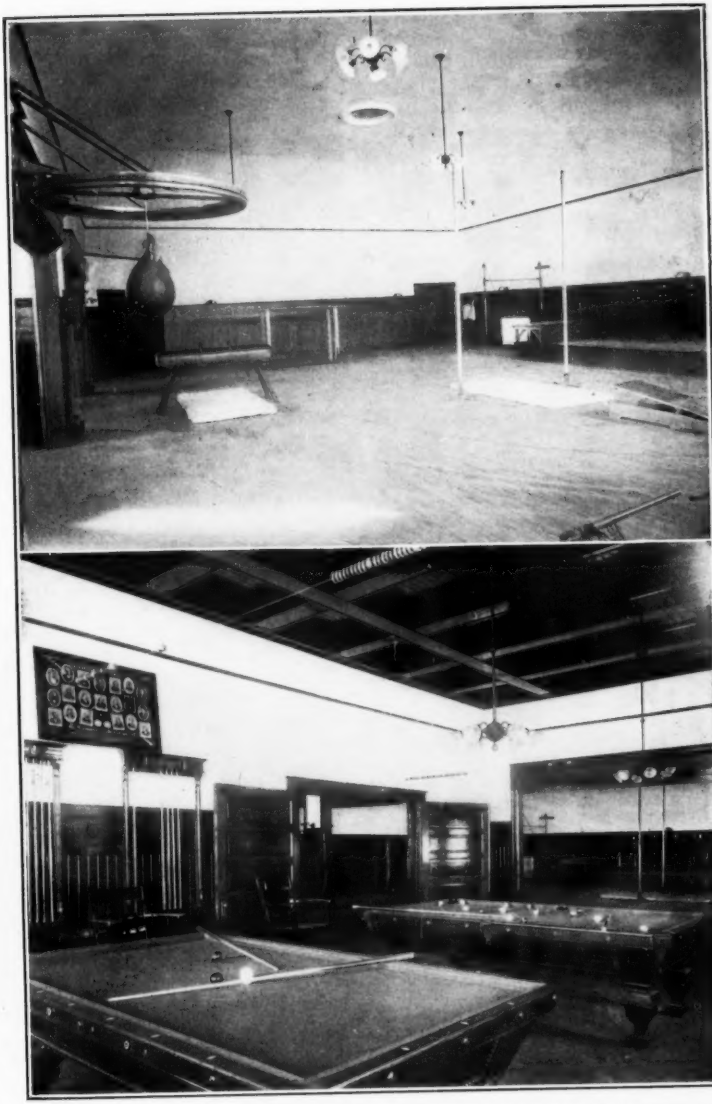
The company has built at this point, without regard to expense,



IN THE NEEDLES RECREATION HALL. THE UPPER VIEW IS THE WEST PORTICO; THE LOWER IS THE UPPER VERANDA AND ROOF GARDEN.

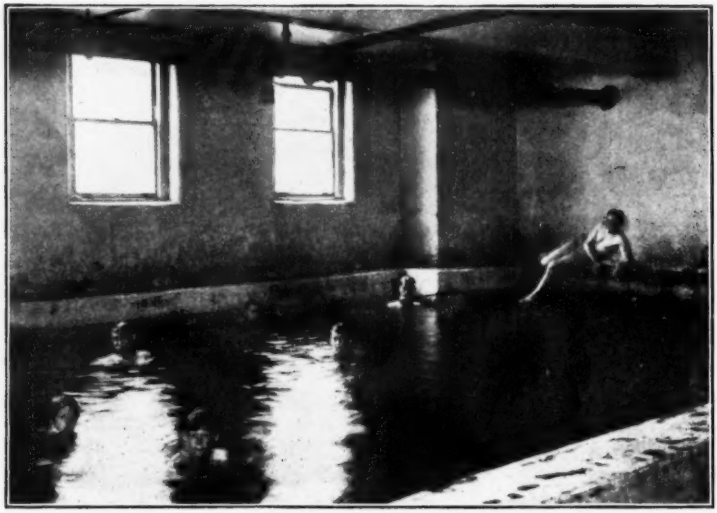


TWO VIEWS OF THE INNER COURT AND FOUNTAIN, THE SANTA FE RAILWAY'S RECREATION HALL FOR EMPLOYEES AT THE NEEDLES, CAL.



GYMNASIUM AND BILLIARD ROOM, NEEDLES RECREATION HALL.

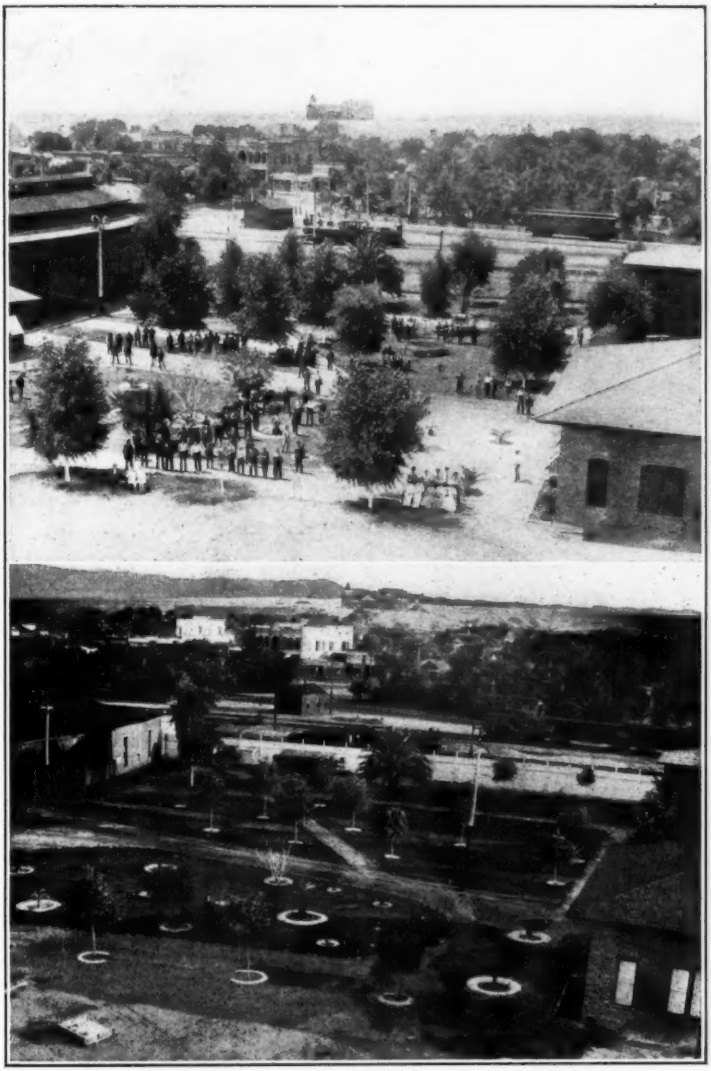
one of its finest recreation halls, in the Mission style; a hospital is maintained, parks have been grown, the shop grounds have been beautified, and cottages have been built. At other points where the conditions are severe, similar measures have been taken, as at Winslow, Arizona, and at La Junta, Colorado.



SWIMMING POOL, THE NEEDLES RECREATION HALL.

In all the principal cities along the railway, hospitals are maintained; each employee, from laborer to the higher officials, pays a small monthly sum (from 25 cents to $1.00) to the hospital association, the aggregate amounting to about $20,000 a month. Some of the trustees of the association are officials of the company, while others are employees. These trustees devote any surplus receipts over expenditures to permanent improvements, new buildings, and additional facilities. Although in this respect self-supporting, this association has received much substantial aid from the railroad in the way of donations to building funds, company buildings rent-free, and other services. All officers and employees of the association, including surgeons, receive transportation free while in the company's service, the same rule applying to injured and sick employees.

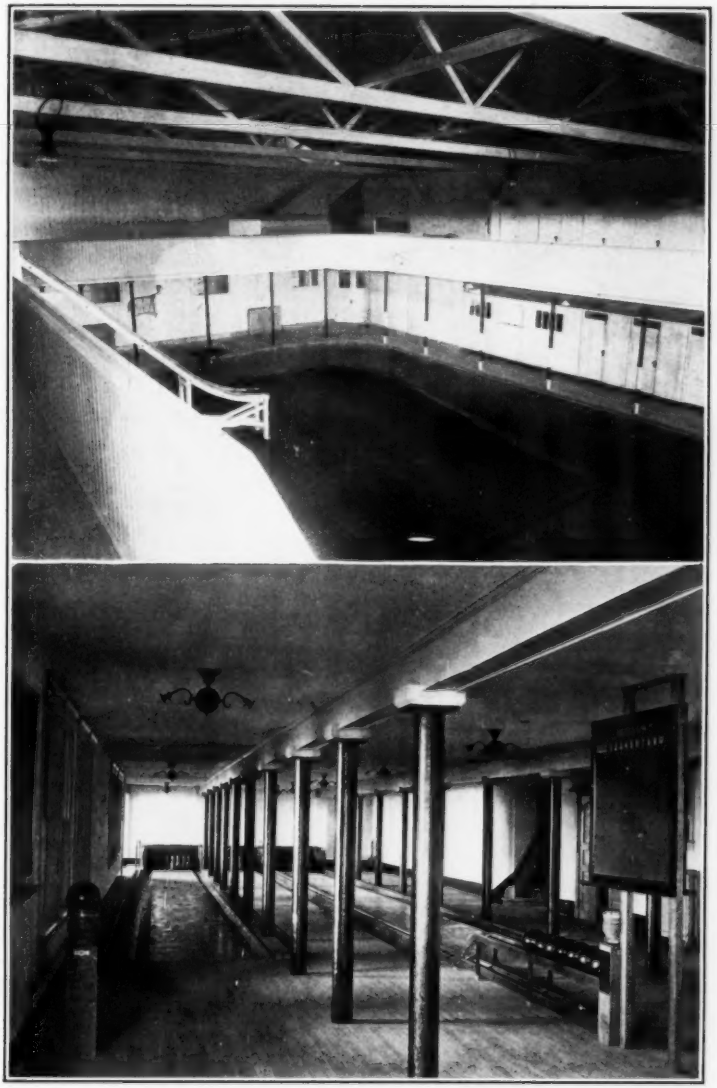
The most notable hospital is at Topeka, where the chief surgeon has his staff of five surgeons, about thirty nurses, and many other employees. At this point from fifty to one hundred patients are in the various wards all the time, not only for injuries received, but also for



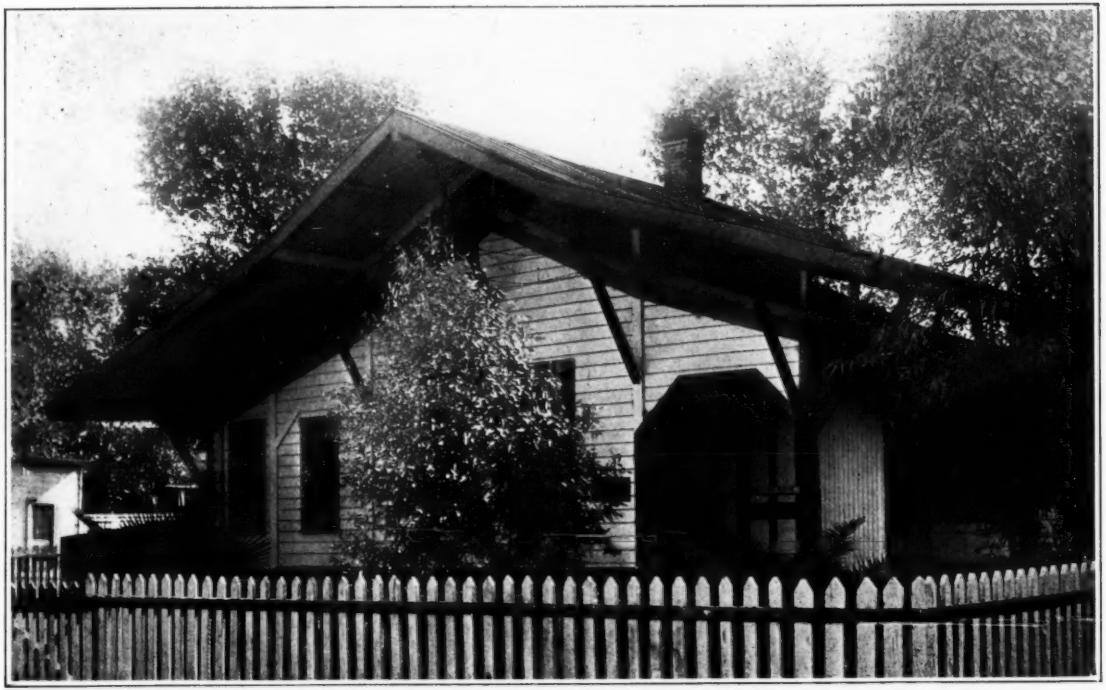
THE SANTA FE SHOP YARDS AT THE NEEDLES.

The lower view shows them at the beginning of the attempt to make them attractive to employees. The upper picture shows them as they are to-day.

THE WRITING ROOM AND THE READING ROOM IN THE NEEDLES RECREATION HALL.



THE SWIMMING POOL AND THE BOWLING ALLEY, NEEDLES RECREATION HALL.



TEMPORARY HOSPITAL AT A DESERT POINT. THE DOUBLE ROOF IS DESIGNED TO ALLOW FREE CIRCULATION OF AIR.

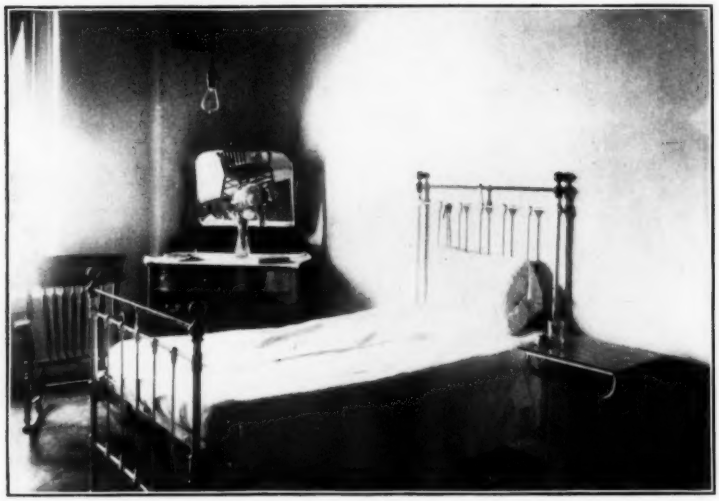
MAIN BUILDING, A. T. & S. F. RAILWAY HOSPITAL ASSOCIATION, TOPEKA, KAS.

sickness. Many serious operations are of course performed. There are many private rooms for severe or special cases. The other hospitals render service similar to that at Topeka, there being about a dozen at various points on the road. Besides these hospitals, which aim to take care of all the cases in their own territory, there are several hundred physicians and surgeons who devote all or part of their time to the company's service at various towns of any size on the road.

In the principal cities ambulance service is provided; in the grounds of the larger shops there are emergency rooms, and in each shop department are men instructed in the "first aid to the injured," regular classes being held at the company's hospital.

Other railroads carry on the same kind of good work, and the time will not be far distant when it is generally recognized that the railroad management, their employees, and the public, have common interests stronger than any differences.

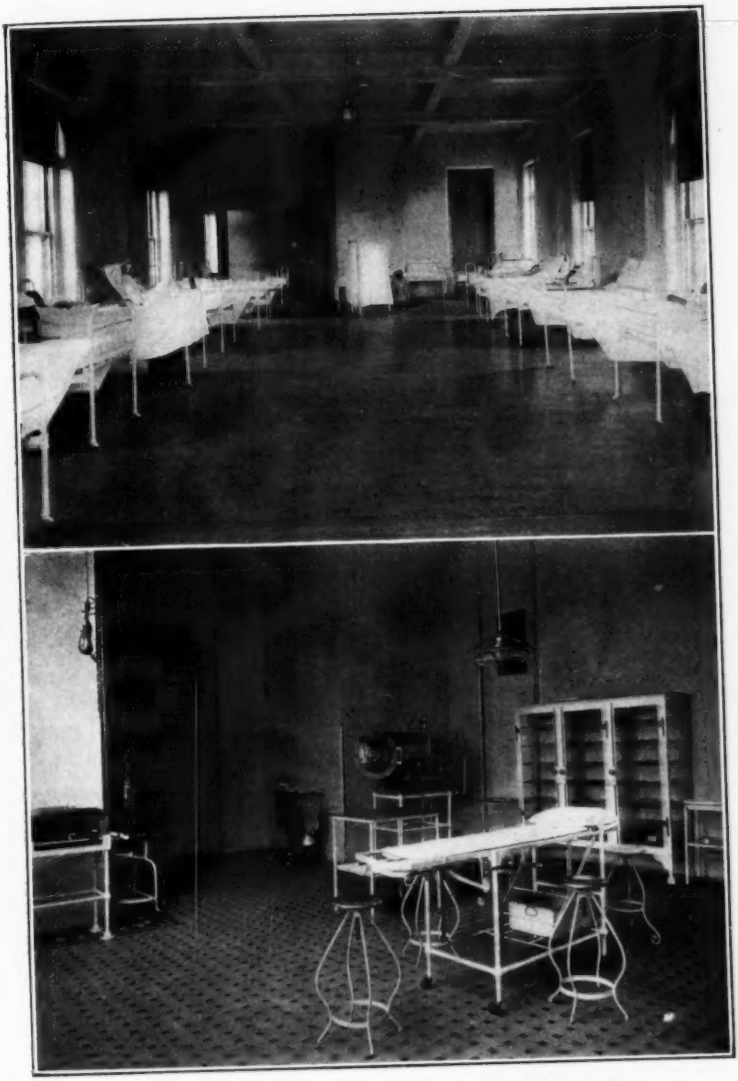
These examples of the interest of the railroad for its employees are not along the line of paternalism, but are in the nature of an investment in the character, health and good-will of the employees.



ISOLATED WARD IN THE SANTA FE HOSPITAL, TOPEKA.

Another advantage that has been instituted is the pension system, and still another of no small importance is the advantage of the employees to get free transportation for themselves and family from time to time.

The pension system is one of the latest institutions established by the company, and while modeled on pre-existing examples, it has been introduced in the belief that its terms are more liberal than those of any pension plan previously enforced. It is carried out wholly at the expense of the company, but under the conviction that the employees will show appreciation of it by increased zeal and loyalty. Nearly every employee has it in his power to benefit his employing company by the character of his work and his influence, or to injure it by carelessness or indifference. The establishment of the pension is based upon confidence that those whose future is thus made safer will in return render the best service of which they are capable.



WARD AND OPERATING ROOM, SANTA FE HOSPITAL, TOPEKA.

NURSES' PARLOR AND REST ROOM, AND DINING ROOM FOR CONVALESCENTS, SANTA FE HOSPITAL, TOPEKA, KANSAS.

The general management of the pension system is in the hands of a board of five officers or employees designated by the president of the railway, and acting under his general direction and during his pleasure. This board adopts its own rules, subject to revision by the board of directors or by the president of the railway company.

THE RAILROAD Y. M. C. A. BUILDING, TOPEKA, KAS.

Pensions may be granted to any retired officer or employee who has served the company continuously for fifteen years or more preceding the date of his retirement, and who, at the time of retiring, has reached the age of 65 years, or who for any cause incident to his employment has been permanently incapacitated for the performance of his regular duty and who cannot be transferred to other work which he is still able to perform. Under this provision the construction is liberal, for in the case of employees of roads leased or purchased the period of service of the employee is construed to date from the time when he entered the employment of the road acquired, and not merely from the time when that road may have passed into the control of the main system.

Further, pensions may not be withheld nor revoked simply because the recipient may have other means of support or may be engaged in other business, if that business is not prejudicial to the interests of the corporation or its auxiliary companies; but the pension board may deny, revoke, or withhold, a pension allowance to any employee if he prove himself wholly undeserving through immorality or other misconduct.

Pensions are not allowable, further, if the officer or employee has made or enforced any claim for damages against the company for injury or accident occurring within three years of the time when the

The Atchison, Topeka & Santa Fe Railway Company.

PENSION DEPARTMENT

PERSONAL RECORD OF SERVICE

*(Date)*_____ *190*___

TO THE BOARD OF PENSIONS,
Atchison, Topeka & Santa Fe Railway Company,
RAILWAY EXCHANGE, CHICAGO, ILL.

I personally make this record of my service with The Atchison, Topeka & Santa Fe Railway Company, and tender it as a basis for being placed on the pension rolls of that Company:

*Name in full*_____ *Address*_____

Employed at present in the _____ *Department*

*at*_____ *as*_____

*Present rate of pay $*_____ *per*_____

*Date and place of birth*_____

*Present age*_____ *years*_____ *months.*

Different employments in the service of the Company and duration of each, with salary attached to each position. (Every change in the place of employment, occupation, immediate superior officer or rate of pay to be shown as a separate term.)

YEARS OF PERVICE	DATES OF EMPLOYMENT.		WHERE EMPLOYED.	BY WHOM EMPLOYED	OCCUPATION	DEPARTMENT	RATES OF PAY	
	From	To					Amount	Per
1st								
2d								
3d								
4th								
5th								
6th								
7th								
8th								
9th								
10th								
11th								
12th								
13th								
14th								
15th								
16th								
17th								
18th								
19th								
20th								

FORM FOR PENSION APPLICATION AND RECORD OF SERVICE.

applicant is retired or leaves the service. Neither are they allowable if, during the fifteen-year period, an applicant has been engaged in business or employment other than the service of the company. The fifteen years must be continuous, and voluntary withdrawal for two months or more is sufficient to constitute a break; but leave of ab-

The Atchison, Topeka & Santa Fe Railway Company.

PENSION DEPARTMENT

TO THE BOARD OF PENSIONS:

.....who has been.....years continuously in the service of the A. T. & S. F. Ry. Co. and is now employed as.....

at.....on the.....1....., reached the age of 65 years and under the provisions of the Pension System may be retired from service. The following statements respecting h..... are submitted for the information of the Board of Pensions:

(HERE SHOULD FOLLOW A STATEMENT OF THE EMPLOYE'S MENTAL AND PHYSICAL CONDITION AND AN EXPLICIT RECOMMENDATION FOR RETIREMENT OR FOR CONTINUANCE IN THE SERVICE.)

.....

.....

.....

.....

.....

.....

.....

(IF RECOMMENDED FOR RETIREMENT GIVE CAREFULLY CONSIDERED STATEMENT OF CHARACTER OF SERVICE RENDERED)

.....

.....

.....

.....

Does employe desire to be retired?.....

Date when last on duty if now disabled.....

Date to which wages were paid if now disabled.....

Signature.....Official Title.....

Date.....Location.....

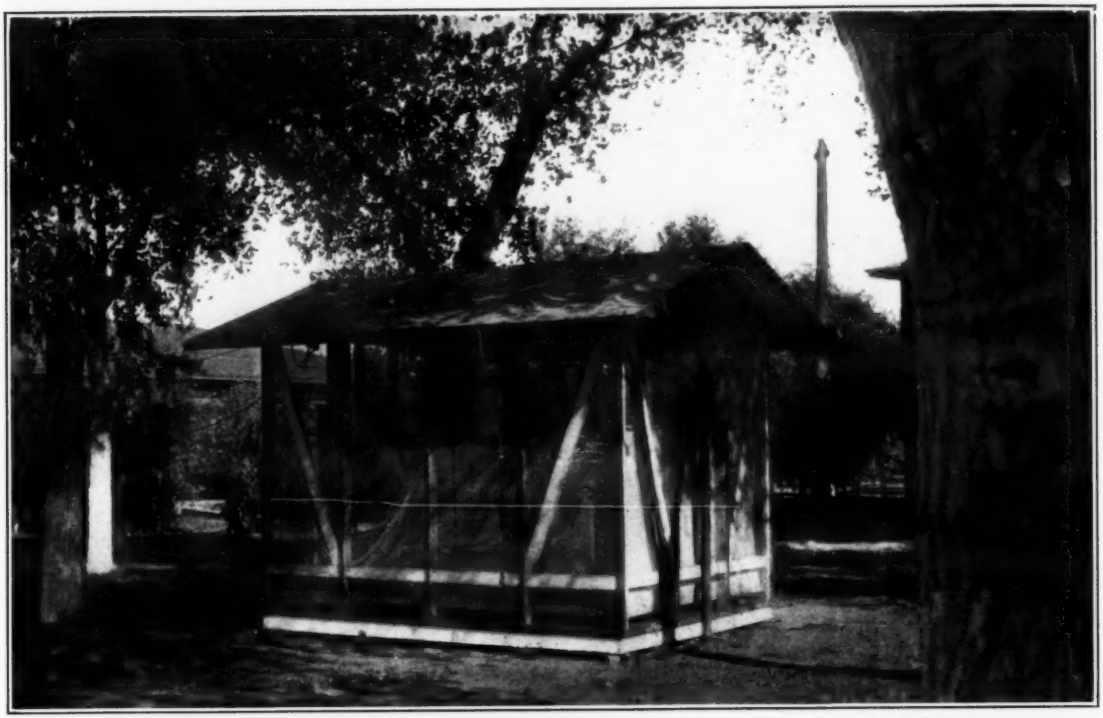
Respectfully forwarded to.....(Date).....

who is my immediate superior officer.

FORM FOR RECOMMENDATION OF AN EMPLOYEE'S PENSION APPLICATION.

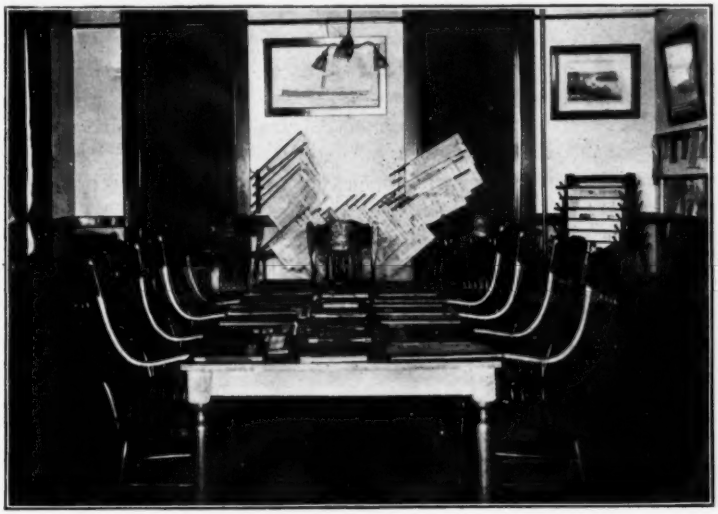
sence duly granted, or even suspension or dismissal if followed by reinstatement within one year, are not regarded as interrupting the continuity of service.

The amount of the pension is contingent upon three elements: (1) the highest average monthly pay received by the pensioner during



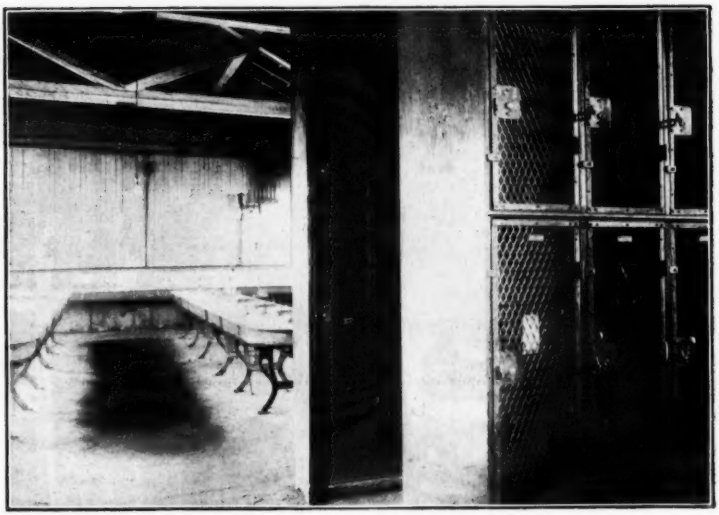
A WIRE-SCREENED BUNGALOW FOR A "BACHELOR" MASTER MECHANIC, SANTA FE RAILWAY.

any consecutive ten years of service; (2) the number of years he has been in the employment of the company or its auxiliary companies; (3) the character of the service he has performed. The general rule is that employees whose highest average monthly wage during any consecutive ten years was $50 or less may receive 1¼ per cent of this monthly average for each year of service, while employees whose pay exceeded $50 per month may be granted for each year of service 1¼ per cent on the first $50 and ¾ of 1 per cent on the remainder. A minimum of $20 a month and a maximum of $75 per month are, however, arbitrarily provided. If the pension computed as above falls below the lower figure it is raised to $20, and if it rises above the higher figure it is reduced to $75. In case of exceptionally long and unbroken service with a first-class record, the board of pensions, with the approval of the president, may increase by as much as 25 per cent any pension as calculated under the preceding rule, provided always that the total sum paid does not exceed $75 a month.



READING ROOM IN THE RAILROAD Y. M. C. A., TOPEKA, KANSAS.

Application for pension is made by filling out a blank, of which reproduction is given on page 348. The signature of the employing officer must be secured in approval, and the application is then passed to the board of pensions through its secretary. In addition to the information called for in the application form the board may ask



SANITARY WASH AND LOCKER ROOM, SANTA FE SHOPS, TOPEKA.

for any further particulars it thinks necessary, and may require a physical examination by the company's surgeon, where the retirement is asked on the ground of incapacity. The acknowledgement of the receipt of the application and notice of the action taken upon it is communicated to the applicant through his employing officer.

The resolution of the board of directors adopting the pension system sets forth that it has been instituted "in order to enable the employees of the company who have rendered long and efficient service to retire when advanced age makes relief from work desirable." This sense of security in old age or in disability incurred in service has proved elsewhere to be one of the greatest incentives to loyalty, contentment, and faithfulness in service. It has as yet found comparatively little application in industrial management in the United States.

By the institution of the system the Santa Fe road seems to be taking a long step toward the betterment of permanent relations between employer and employed. The probability that it will be fully justified and repaid by the results does not diminish in the least the credit due to the far-sightedness and the praiseworthy effort of those who are responsible for its introduction.

HYDRO-ELECTRIC POWER VERSUS STEAM FOR INDUSTRIAL PLANTS.

By H. von Schon.

III. TYPICAL MODERN STATIONS AND OPPORTUNITIES INVITING DEVELOPMENT.

In an initial article appearing in the April issue of THE ENGINEERING MAGAZINE, Mr. von Schon drew a comparison and contrast between hydro-electric power and steam in point of availability, efficiency, and cost. A second installment took up the method of making a commercial study of a water-power proposition. In this third paper the treatment is very concrete. Three characteristic plants of widely varying types are described as examples of what has been done, and a list of about fifty as yet undeveloped water powers is appended to show the wealth of opportunities ready for improvement. A concluding article next month will review the engineering study necessary in examination of a project of this kind.—THE EDITORS.

IN offering descriptions of hydro-electric plants I have selected three of the more recent developments, representing distinctly different programmes and some of the latest hydro-electric structural types.

One of the largest low-head water-power developments was completed four years ago at Sault Ste. Marie, Mich., at the lower end of Lake Superior, abreast of the Sault Ste. Marie rapids. The contributing drainage area contains about 50,000 square miles, of which the lake covers 30,000, the normal annual precipitation over this area being 30 inches; the monthly outflow of Lake Superior fluctuates between 58,000 and 120,000 cubic second feet, the lesser volume prevailing during the frozen period. The fall represented by the Sault rapids varies from 19 to 20 feet in accordance with the upper and lower stages; the normal level above the rapids is at elevation 601.5 feet, and that at foot of rapids is 582.0 feet.

The International boundary line lies somewhere in the rapids; its definite position is unknown, and the waters are theoretically divided between the United States and the Dominion of Canada.

The Sault Ste. Marie River, which should be more properly called a "strait," connects Lakes Superior and Huron and is navigable, the rapids being passed by means of the largest locks in existence; both Governments exercise control over the waters in the river and the rapids, and the title to two islands is in dispute. Large quantities of logs pass out of Lake Superior by way of the rapids, the use of

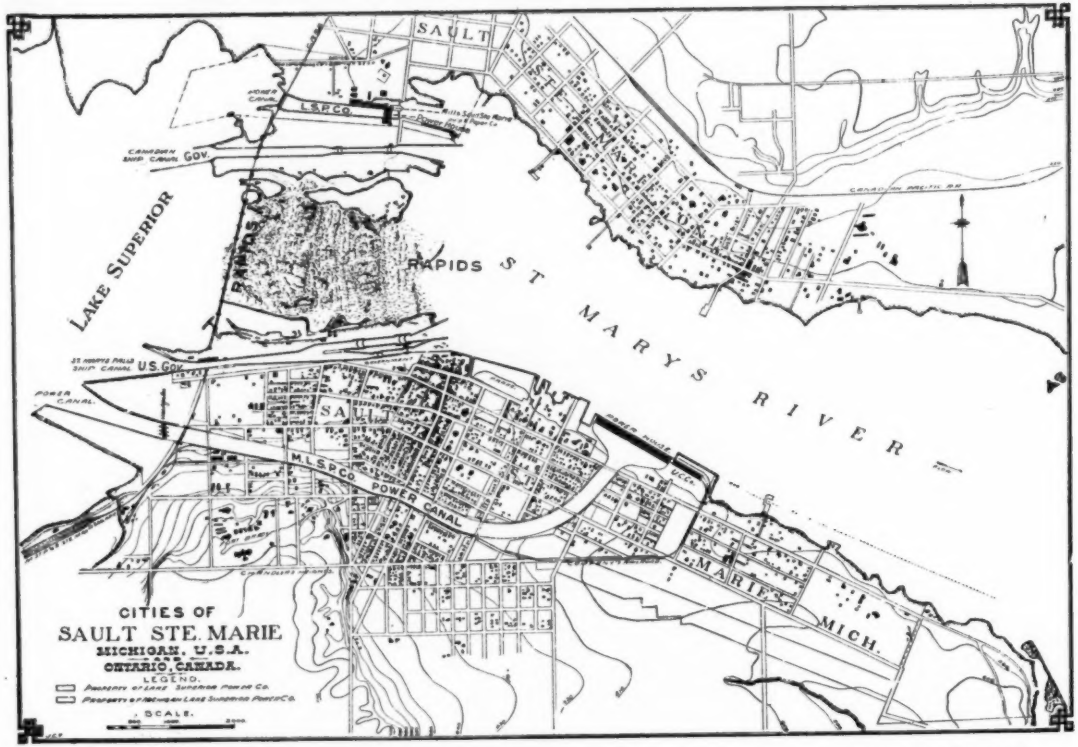


FIG. I. GENERAL MAP OF THE SAULT SHOWING THE TOPOGRAPHICAL RELATIONS OF THE MICHIGAN-LAKE-SUPERIOR POWER COMPANY'S UNDERTAKING.

the locks not being available for this purpose, and the important interests of Lake shipping are readily affected by even a slight lowering of Lake Superior level beyond the natural fluctuations. These facts are cited because each one of them proved of importance in the consideration of the development programme.

It does not require an expert to conclude, after general preliminary examination of the physical conditions, that the simplest and most economical development plan at that point consists of constructing a spillway across at the foot of the rapids, connecting it to shore embankments, and passing the flow through turbines placed within the spillway or in stations at its ends; but a casual survey of the conflicting conditions of control and ownership on these rapids suffices to negative such a programme. Diversion of the flow around the rapids was the only solution.

The city is built along the river shore, back to a range of hills; the Government canal extends half a mile above the rapids, and the locks and Government docks for a like distance below; the location of the diversion canal was therefore of necessity through the heart of the city; its intake was determined above the Government canal entrance, and the terminal below the Government docks. This was an exceedingly costly plan as compared with the logical one in the rapids, the canal being some 2½ miles long, 300 feet wide, and its cuttting from 30 to 35 feet deep, more than a mile of it through Potsdam sandstone ledge; the cost of this canal alone was about five times that of the probable cost of a dam across the rapids. The sandstone hogback which here crosses the river drops immediately below the rapids to a depth of 50 feet and more, and thus the terminal of the canal and the dam and power house, necessarily located there, had to be placed on pile bearing foundations, which added largely to their cost. Adverse criticisms have been freely passed upon the development as carried out, but evidently their authors were ill informed as to the conditions which forced it upon the power company and the designer.

Figure 1 shows the location and development, in which the conditions just described will be readily recognized.

The flow capacity of the canal is 30,000 second feet; its prism, where passing through rock, is rectangular, and in the other section trapezoidal; near its terminal the forebay is located, and is closed by the power house, the sub-structure of which forms the dam; this structure is 1,368 feet long, paralleling the river shore. The water passes through the power house into the river one-half mile below the rapids, the effective head being 18 feet.

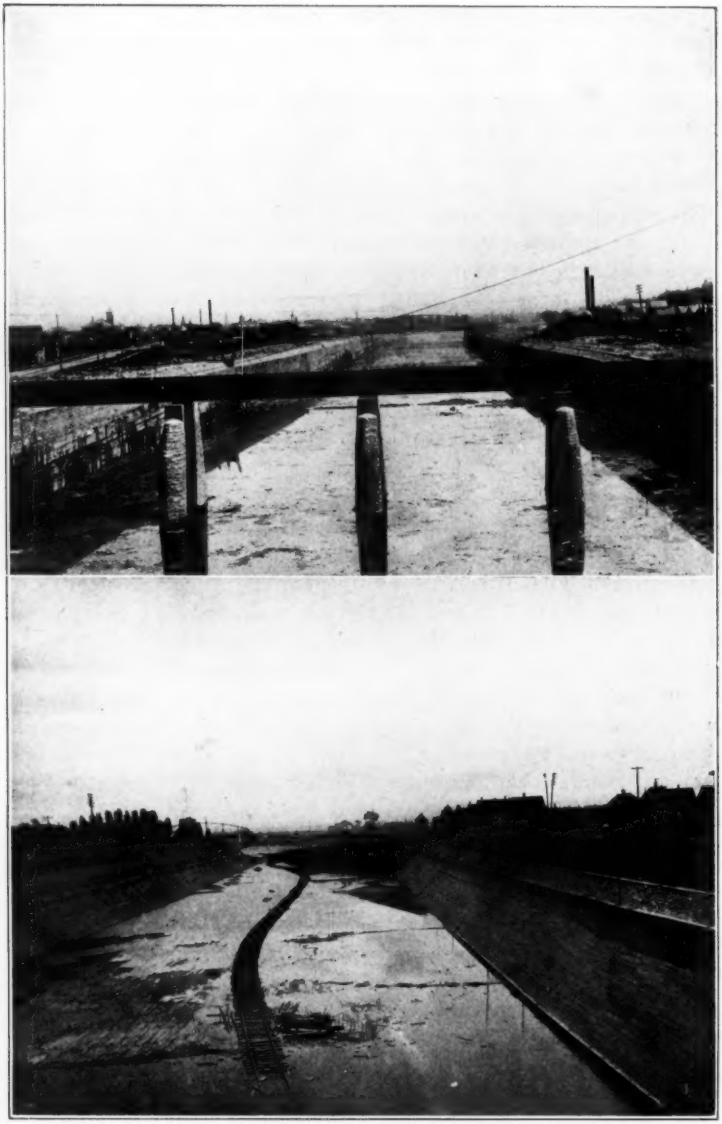


FIG. 2 AND 3. TWO VIEWS OF THE CANAL, THE UPPER IN ROCK AND THE LOWER IN EARTH SECTION.

The construction of all works is of the best for the purpose; the rock canal prism is channelled, the earth section is timber-lined throughout, the upper slopes are paved; Figures 2 and 3 are representative of these. The forebay is of same construction as canal, being timber-lined and floored, and across its throat is placed an intercepting rack, which appears on page 361 looking toward the power house. This latter is the largest structure of its kind, its length exceeding a quarter of a mile; it rests upon a timber grillage and concrete foundation supported by some 12,000 piles driven to rock. This

FIG. 4. UP-STREAM VIEW OF MOVABLE DAM OR HEAD GATE, SAULT POWER CANAL.

is probably one of the first structures in which concrete blocks were used instead of shaped stones for ashlar masonry walls; these blocks, about 8,000 in number, were generally 3 by 3 by 5 feet, formed with tongues and grooves, as appears in Figures 5 and 6. All the substructure was so built; it consisted of 81 chambers—pits—enclosed at three sides by walls of these blocks, as shown in Figure 5, the up-stream closing wall being of the same material but arched. Concrete-steel practice was in its infancy in 1898, but more of it was placed in the Sault power house than in any other single structure since; the pit roofs are concrete-steel arches; the 81 penstocks, or turbine chambers, placed upon the pits, are separated by concrete-steel partitions, and the mill floor above the penstocks, 1,296 feet long and 85 feet wide, consists of 81 concrete-steel arches of 16-foot spans. The

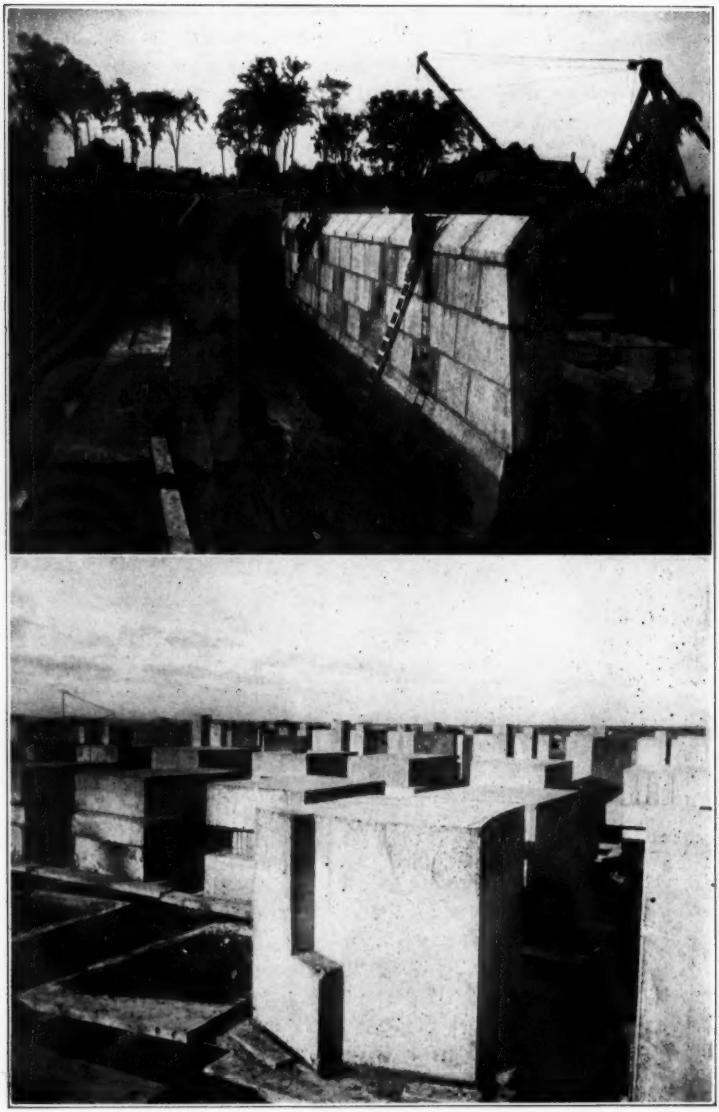


FIG. 5 AND 6. PIT WALLS AT EAST END OF POWER HOUSE, AND PART OF THE FOREBAY, SHOWING GROOVED CONCRETE-BLOCK CONSTRUCTION.

down-stream closing of the turbine chambers was of original design, being an arched steel bulkhead (see Figure 8) semi-circular, of 7½-feet radius, 28-feet high, built of ¼-inch mild-steel plates anchored to the concrete floor, which takes the place and performs the duty of the usual masonry gravity wall of heavy section. The building itself, of which an up-stream view is shown on page 361, is constructed of the sandstone excavated from the canal and contains, in addition to the 81 turbine chambers, some 2,360,000 square feet of floor space, or about 5½ acres.

FIG. 7. DOWN-STREAM VIEW OF HEAD GATE, MICHIGAN-LAKE-SUPERIOR POWER COMPANY'S CANAL.

The entrance to the canal is guarded by gates of the Stoney sluice type shown above, while a similar structure stands at the head of the rapids, serving the purpose of reducing the natural outflow of Lake Superior and controlling the fluctuations.

The power-output units were fixed at 500 electrical horse power and a shaft speed of 180 revolutions, this being the requirement of one of the largest power customers and the best adapted for pulp grinding, for which the power was to be largely utilized. The capacity of the plant is 50,000 mechanical horse power. The equipment consists of 80 units of four 33-inch reaction turbines, placed horizontally on one shaft, which passes through the steel bulkheads and allows of

coupling of generator or pulp-grinder shafts; Figure 12 shows some of these in place.

The cost of the total development was about $4,500,000. Commercially the enterprise has not yet attained the success which it deserves and will, no doubt, before long realize; 20,000 horse power are leased to the Union Carbide Company for the manufacture of calcium carbide; the east half of the power house is utilized for this purpose, electric power being generated by 375-kilowatt alternators, 60-cycle, single-phase, 200-volts; the current is carried by bus-bars to electric furnaces on the mill floor above; in these a mixture of coke

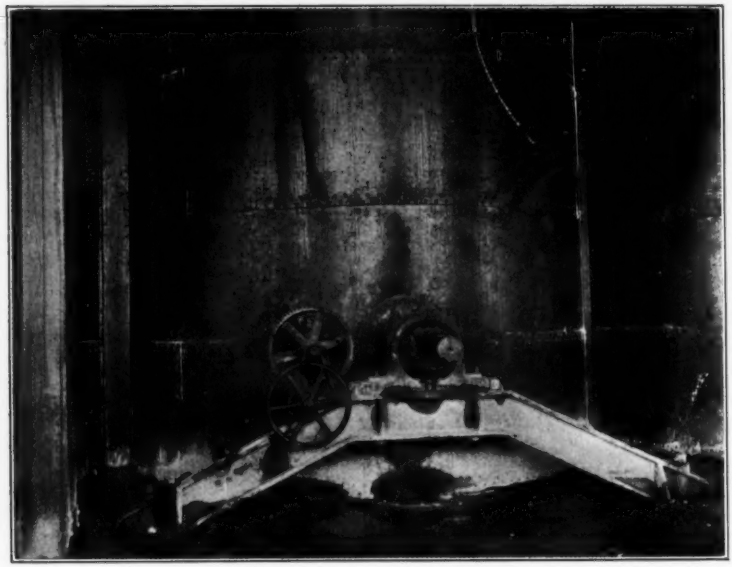


FIG. 8. ARCHED STEEL BULKHEAD CLOSING THE TURBINE CHAMBERS, SAULT ST. MARIE.

and limestone is fused at a temperature of 4,000 degrees F., the product being calcium carbide, from which acetylene gas is generated. A street-railway system is being operated, and some lighting and motor current is furnished in the city. The early purpose was to utilize a large part of the output for grinding wood pulp from Canadian sources; this was defeated before completion of plant by an embargo placed upon export of Canadian pulp wood. The construction of a large paper mill designed to use some 3,000 horse power was interrupted in 1903 by the financial difficulties which overtook the company; a large tube-mill, which was to utilize some 8,000 horse power, was also contemplated and all the machinery was on hand at the

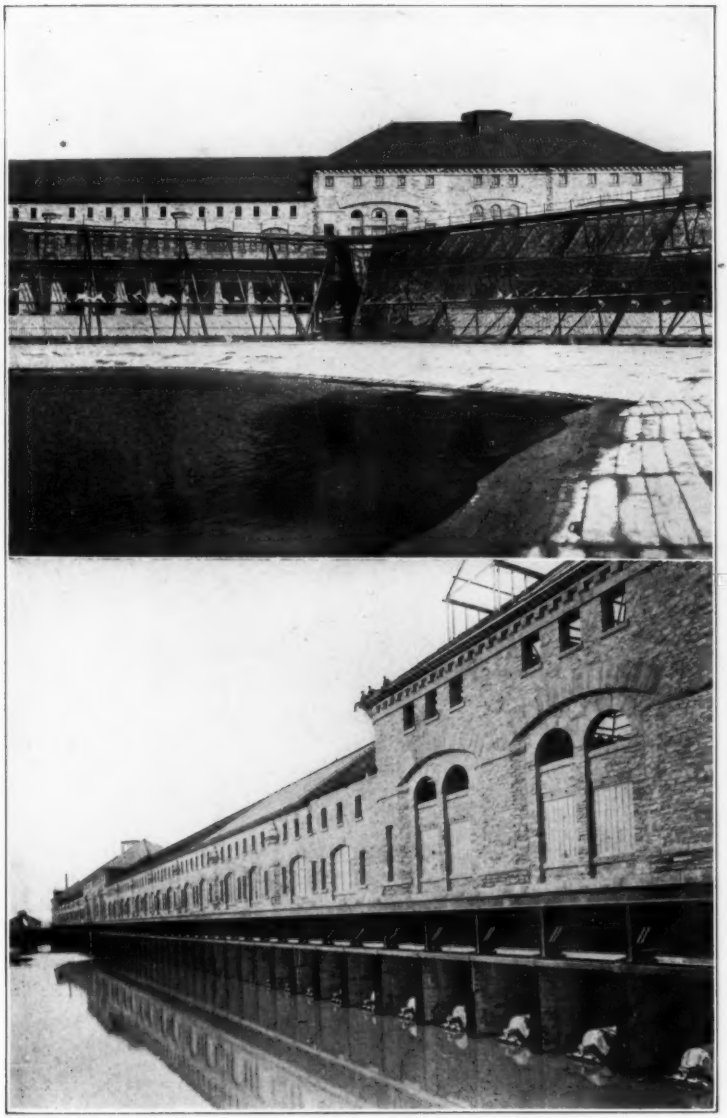


FIG. 9 AND 10. POWER HOUSE OF THE MICHIGAN-LAKE-SUPERIOR POWER COMPANY, SAULT ST. MARIE.

The lower view shows the general up-stream front; the upper shows the ice rack, from the bottom of the canal.

time of the financial crash; so was the machinery for a large paper-bag plant to be located in the power house—in fact, in another year or two all the power would have been disposed of. Nevertheless, the expectations of the originators will sooner or later be realized; the electric reduction of ores has now been practically developed at the Sault, and with the advantageous water transportation and proximity to the large copper deposits, this industry alone will before long use every horse power. The plant is designed and built for permanency and economy of operation and maintenance; the revenue from the present 20,000 horse-power contract will practically meet fixed charges and its ultimate commercial success can therefore not be stayed.

The hydro-electric development of the Georgian Bay Power Company, Ltd., of Toronto, Can., forms the second subject of description. This development is located in the Georgian Bay district of Ontario, its subject being the picturesque Eugenia Falls, which are situated on the Beaver river, emptying into Georgian Bay, Lake Huron. The contributing drainage area is 200 square miles, the available flow 80 cubic second feet, and the effective head 400 feet.

The development programme is of the distant diversion plan, the river being closed by a spillway and reservoir dam at the village of

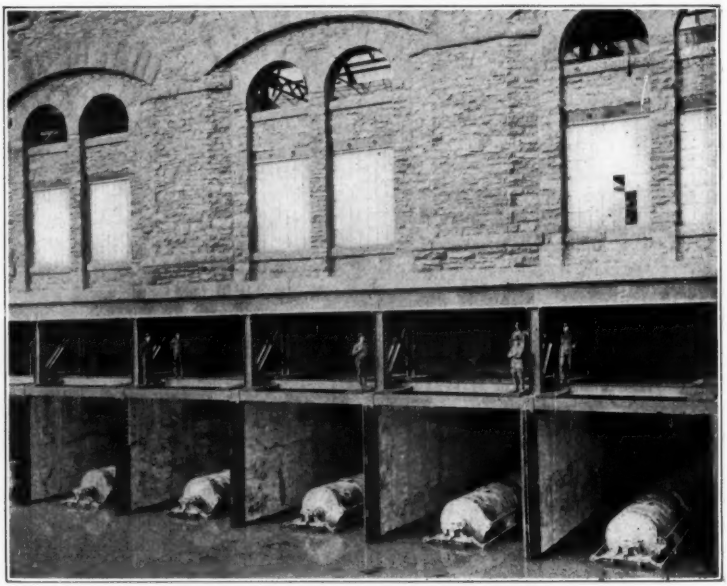


FIG. II. ENDS OF THE PENSTOCKS, SAULT POWER PLANT.

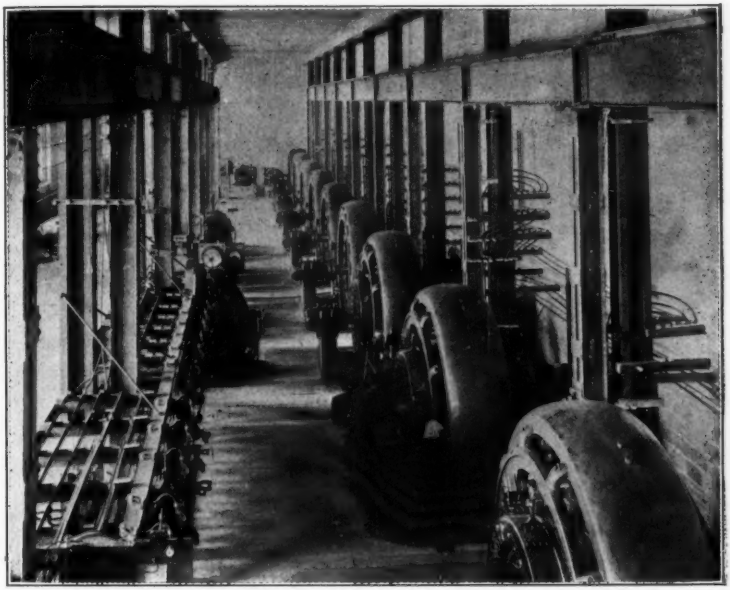


FIG. 12. INTERIOR OF SAULT POWER HOUSE. ELECTRIC-GENERATOR SIDE.

Eugenia, whence the water is conducted by a steel-pipe pressure line some 3,500-feet long to the power house on the river; the plan on page 364 outlines this programme. The distinctive features of this development are the dam, being of the Ambursen concrete-steel shell type, reservoir concrete-steel bulkheads, and the passage of the pressure line in part through a tunnel.

The spillway structure is representative of the latest development in dam designs. While the solid masonry or concrete dam (until recently considered the only safe and permanent device to impound flowing water) resists the pressures by its weight, this latter design utilizes the water pressure to maintain its position, through the adoption of a triangular form of such shape that the weight of water upon it equals the horizontal pressure component; this principle could be adapted to the solid type but would require such a large mass that its cost would be prohibitory, while this structure consists of a shell of concrete-steel in which the necessary strength and rigidity is secured by a very small fraction of the quantity of material needed in the solid structure. The advantages of such a type are manifold; its comparatively light weight requires less costly foundation and diminishes the danger of settlement and consequent cracks; the interior

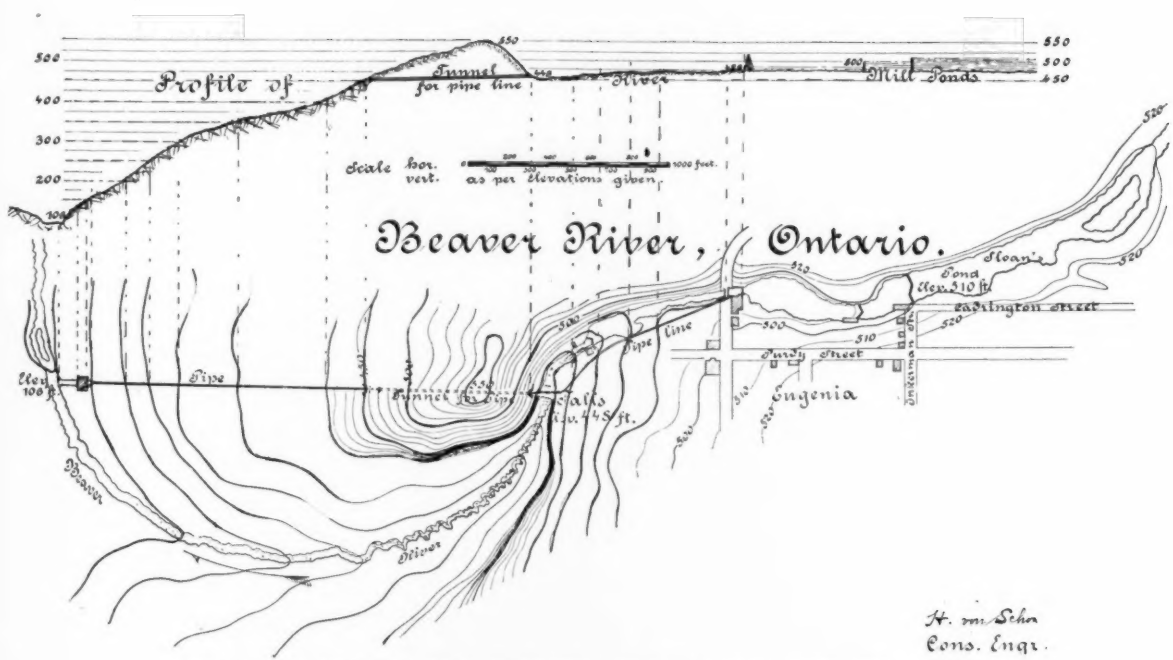


FIG. 13. MAP SHOWING GENERAL TOPOGRAPHY AND FALL, EUGENIA POWER INSTALLATION.

steel-bar net binds the whole into a homogeneous mass, imparting to it a greater resistance to the influence of fluctuating temperatures; danger from underwashing is minimized, since its stability, being independent of inherent weight, is not reduced by upward hydrostatic pressures, as is the case with solid dams; the flow during construction can be more readily and economically controlled, and the structure can be built in considerably less time than the solid dam; and, finally, the interior is accessible, can be inspected, repaired, utilized for arrangement of waste flumes and flashboards, and last, but not least, for the housing of the power equipment, as will be described more particularly in connection with the third plant to be discussed. The progressive construction of such a spillway is illustrated by accompanying views.

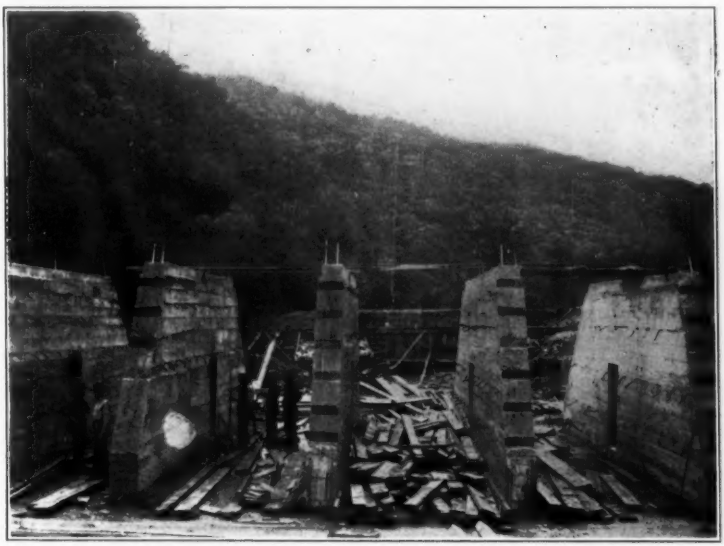


FIG. 14. SPILLWAY UNDER CONSTRUCTION ON THE JUNIATA RIVER.
Showing the reinforced-concrete buttresses. This is identical in type with the Eugenia installation. By courtesy of the Ambursen Hydraulic Construction Co.

The Eugenia spillway is 80 feet long and 40 feet high and consists of seven transverse concrete-steel partitions, or buttresses, of triangular shape, the up-stream ends on slope of one in one, the down stream one half in one; these are anchored to a rock ledge, 10 feet centers and 22, 18, and 12 inches thick from bottom up. The up-stream ends are covered by the concrete-steel deck, 24 inches at bot-

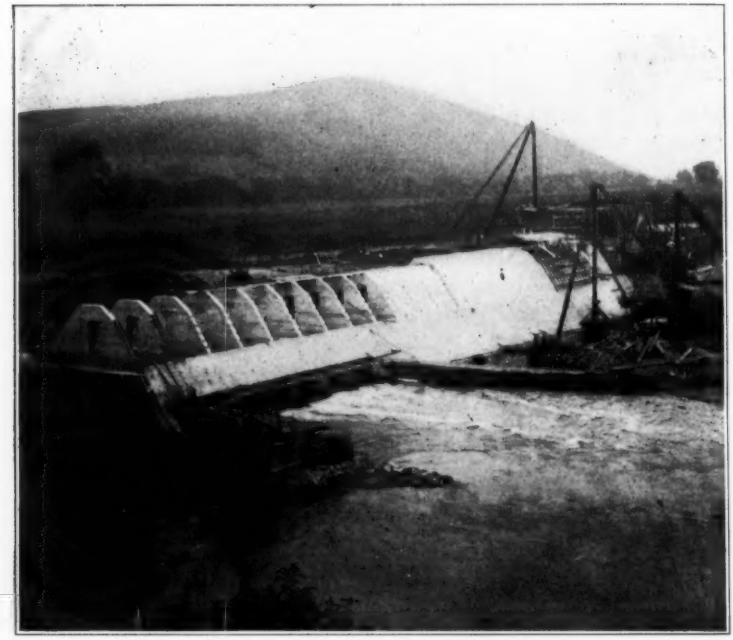


FIG. 15. THE JUNIATA SPILLWAY, PARTIALLY COMPLETED.
By courtesy of the Ambursen Hydraulic Construction Co.

tom, 12 at top, the down stream by the apron, the two being connected at top by the crown, 2 feet thick, 5 feet wide. Deck and apron are water-tight structures, their sections being sufficient to resist bending under water weight; openings are left in the buttresses, allowing of passage through the interior from end to end and preventing accumulation of lateral hydrostatic pressures against them; air vents are placed through the apron under the crown, creating free circulation, and thus avoiding formation of a vacuum beneath the overfalling sheet of water. The spillway is closed by concrete-steel buttresses, entrance to the interior being obtained through doors opening on the down-stream side. The complete closing of the river valley from bank to bank, some 1,000 feet in width, is accomplished by reservoir bulkheads, being of same design as the above described spillway minus the apron and rising six feet above the spillway crest, being safely above the highest probable pond level. These, as well as the spillway type, represent a departure from past reservoir structure practice, which had heretofore almost always adopted earth embankments with

some kind of an interior core. The concrete-steel bulkheads are more economical in cost and absolutely permanent.

Water passes into a well on the south side of the spillway, to which is connected the 54-inch steel pipe conducting it to the power house three-quarters of a mile distant; on its way it crosses the river just above the falls and, curving northerly, pierces a bluff 150 feet high. The tunnel is 10 by 11 feet, lined with cedar which is obtained at the site; the pipe rests on timber frames. Emerging from the tunnel the pipe is reduced to 48 inches for 1,000 feet, passing down the hill side at a 10 per cent grade, and then to 36 inches, taking its final plunge down a steep incline. Concrete anchorages are distributed along the pipe-line location, and its terminal consists of a concrete bulkhead where it is separated into two 24-inch feeder pipes, each leading to a separate turbine in the power station.

The power house is of concrete and steel frame, 40 by 50 feet; the tail race is a concrete-steel flume.

The equipment consists of two Swiss wheels of the volute type; generators are coupled to the turbine shafts. The highly refined turbine installation presents many interesting features of controlling

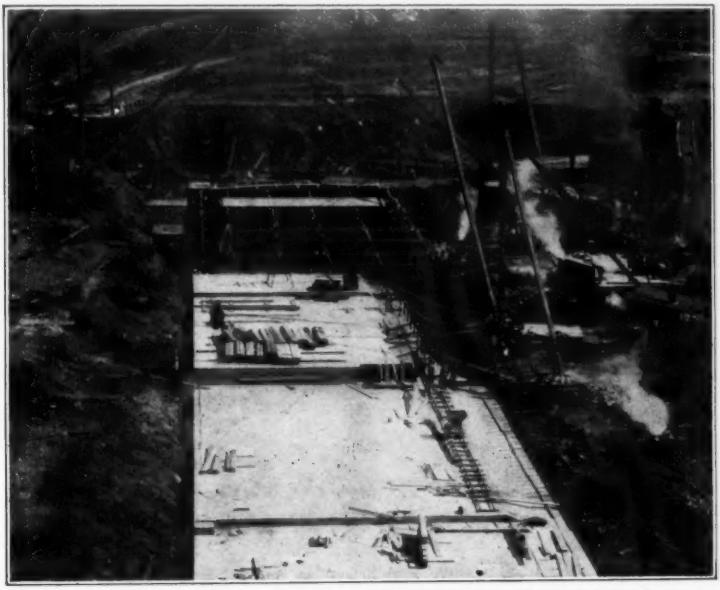


FIG. 16. FLOOR OF THE JUNIATA SPILLWAY, IDENTICAL IN TYPE WITH THE EUGENIA.
By courtesy of the Ambursen Hydraulic Construction Co.

the water and governing the output. The capacity of the plant is 2,500 electrical horse power, all of which is transmitted at a pressure of 13,000 volts on single-circuit three-phase line, to Owen Sound, Ont., 38 miles distant, where it is sold to cement plants, industrial shops, ship-yards, and for lighting, the rates being from $35.00 per horse power up.

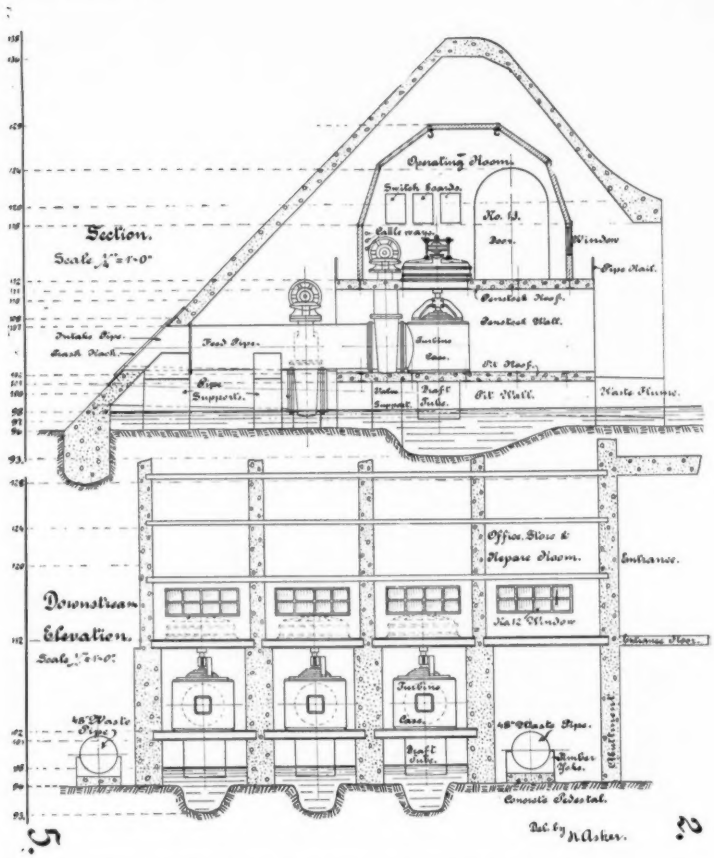


FIG. 17. CROSS SECTION AND ELEVATION OF THE PATAPSCO SPILLWAY, WITH INTERIOR POWER HOUSE.

The third subject to be described is the recently completed hydro-electric plant of the Patapsco Electric Mfg. Co., on the Patapsco River near Ilchester, some 16 miles from Baltimore, Md., on the B. & O. R. R. This is a re-development of a water power long ago harnessed,

FIG. 18. A VIEW OF CONSTRUCTION WORK ON THE PATAPSCO SPILLWAY.

on a site formerly occupied by a timber dam; its peculiar feature of interest is the power station, which is placed in the interior of the spillway and is the first of this type yet constructed.

The spillway is of the concrete-steel shell type just described, 245 feet long and 38 feet wide; the apron extends only half way down from crown, the remaining down-stream portion being entirely open. It is founded on a rock ledge and closes the entire river valley. With the foregoing description of the hollow dam the arrangement of the interior power station will be readily understood. The hollow spillway is divided by buttresses into chambers which are utilized for the placing of equipment. For this purpose a concrete-steel floor is placed at a proper elevation above the lower pool, between buttresses, the latter being increased in section below this floor; a housing of hollow-tile walls and roof is placed upon the floor, leaving an air space between it and the spillway shell. The turbines, in cases, are placed on this floor; their installation may be on horizontal or vertical shaft, in accordance with the height of chamber available; water is brought to the turbines by means of steel feed pipes passing through the up-stream spillway shell, and discharged by draft tubes into the base of the dam, dropping into a well sunk some three feet below the river bed; it passes thence by way of a channel constructed in the river bed, out of the dam. The flow through the feed pipe is controlled by a valve-gate operated from the turbine chamber; a trash-

FIG. 19 AND 20. SPILLWAY OF THE PATAPSCO HYDRO-ELECTRIC POWER INSTALLATION. The upper view shows the hollow form of the spillway. The lower illustrates the completed structure, with the openings for windows lighting the interior power station.

rack is placed in front of the intake to the feed pipe. The advantages of such an arrangement are readily discerned; the dam foundation and structure are the power house; the chamber is absolutely free from moisture, by reason of free circulation of air around it; the development utilizes all the available fall, and during periods when water passes over the spillway crest its suction force as it passes the mouth of the tail race lowers the water level in the tail-race well and thus increases the effective head, which would be reduced were the power house located below the dam.

The chamber receives light through windows on the down-stream side, air through ventilators, and there is ample room to move, install, and repair any part of the equipment. The generators are coupled to the turbine shaft. The installation is compact, secure, and of highest practicable efficiency as far as it can be obtained from flow and fall. The cost of the power station is, of course, very much less than that of any other arrangement.

The sections and views here given illustrate the structure, which is practicable wherever the spillway is 30 feet high, or higher. This station contains three power units, with output of 1,650 horse power, all of which is used by the Patapsco Electric Mfg. Co., but it would accommodate as many units as there are spillway chambers. The plant was constructed by the Ambursen Hydraulic Construction Company, of Boston, Mass.; the design was developed and patented by me.

I have collected data of undeveloped water powers in America for several years and their number is surprising. Generally speaking, they may be divided into three classes—the powers which are entirely unimproved as yet and controlled by private interests, those of the waste flow passing over the dams at Government locks, and those depending upon the re-organization and modernizing of the old mill powers, many of which are now idle, none of them having been originally developed to their available capacity.

Space will permit quotation of a few, only, and a selection has therefore been made, chiefly from those which I have personally examined, and of which I am in a position to present the essential facts. The flow referred to in these descriptions is the available power flow, or the low flow replenished from obtainable storage to meet the normal conditions; the fall is the effective working head; output capacity is given in electrical horse power at the generator switchboard, and cost represents the works and generating equipment. The names and addresses of parties controlling the opportunities are given to enable possible investigators to direct their inquiries to the proper people. The list appears on the following pages:

ALABAMA.

1. Black Warrior River. At Locust Fork a succession of several falls can be developed with available storage. Mr. E. J. McCrossen, of Birmingham, Ala., controls the sites together with large acreage of what is represented to be valuable timber land. Mr. McCrossen states that 325 feet fall can be had and 2,500 horse power developed economically at a point about 25 miles from Birmingham, Ala. I have not seen an engineer's report on this project.

2. Tallapoosa River. What is known as the Cherokee power site is controlled by the Cherokee Development and Manufacturing Company, of Birmingham, Ala. This opportunity has been exploited by engineers' reports for some time; the power site is at a rock gorge, 150 feet wide, with river expanding above and below to more than 1,000 feet; ample storage appears to be feasible. A fall of 100 feet is said to be available and, in a report made by Mr. Henry C. Jones, of Birmingham, Ala., a continuous output of 18,000 horse power for 10-hour service is claimed as potential with additional power available during all but low season. An estimate of development and delivery to Birmingham, Ala., 100 miles, is presented in that report, aggregating $2,500,000.

3. Coosa River. Near the crossing of the Seaboard Railroad in St. Claire and Calhoun counties is a proposition which has been promoted for some time by the Coosa River Electric Power Co., of Birmingham, Ala., Mr. Roswell H. Cobb, president; it has been surveyed and reported on by Robt. R. Zell, of Birmingham. This development is planned, under Congressional act passed last year, at Government Locks Nos. 2, 3 and 4, by construction of a new dam and raising of levels whereby a fall of 36 feet is said to become available, and a power output of probably 12,000 horse power. I have not seen a detailed cost estimate; it is likely to reach $100 per horse power. Gadsden, Ala., is 15 miles, and Anniston, Ala., 14 miles from the site, and these points are alleged to offer good markets.

4. Big Wells River. In Etowah county, about 1½ miles from Attalla, Ala., it is reported by the Etowah Light & Power Co., Mr. A. Brown, Mgr., of Etowah, Ala., a fall of 17 feet can be secured and a development of about 1,000 horse power. The dam location is in rock; the power house would be at the end of the dam. The current is to be used by the company in their plant in Etowah, now run by steam.

5. Little River. A power site in Cherokee County (the nearest town being Menlo, Ga., 9 miles distant) is described by Mr. H. J. Lawrence, of Menlo, Ga., as being capable of developing 10,000 horse power by erecting a dam 55 feet high and 1,500 feet long, and by 1½ mile diversion of flow, securing a fall of 550 feet. The river at the dam site is reported to be in sandstone. I have not seen an engineer's report on this development, but it appears to possess the elements of an economical opportunity. Gadsden, Ala., is 30 miles and Rome, Ga., a like distance; these are both good market points.

6. Tallapoosa River. Another power on this stream is in Tallapoosa County, about 6 miles from Alexander City, Ala., about ½ mile from the main line of the Central R. R. of Ga. Mr. R. A. Chapman, of Montgomery, Ala., now at the U. S. Engineer's Office in that city, has surveyed and reported on this power and states that a dam 85 feet high and 500 feet long

can be placed in a granite rock location, creating 80 feet of working head and an output of 6,000 horse power. Montgomery is 47 miles, Birmingham 60 miles from the site.

7. PEA RIVER. The Pea River Power Co., of Elba, Ala., Mr. H. D. Boyd, secretary, advise that they control several power sites which can be economically developed and the output marketed at Elba and Troy, Ala. I have no details of fall, development programme, or cost.

ARKANSAS.

8. KINGS RIVER. In Carroll County, 1½ miles from the town of Grand View, the Kings River Electric Power Co. control a site reported by them to permit of placing in rock location a dam 22 feet high and 325 feet long, thereby creating a fall of 21 feet and securing an output of 1,000 horse power. The dam can be built for $30,000 and $70 per horse power will probably cover the development cost. I have not seen an engineer's report on this project. The market will be at Eureka Springs and Berryville, Ark., 10 miles distant.

9. LITTLE MISSOURI RIVER. The Southern Power & Development Co., of Ozark, Ark., Mr. D. A. Allen, president, have a site in Montgomery, Ark., where a 65-foot high dam 235 feet long can be placed in a rock gorge. The company state that they can develop 1,000 horse power, but have not submitted any engineer's report. Market for current would be at Black Springs, 25 miles, and other points.

COLORADO.

10. TAYLOR RIVER. Mr. Albert B. Sandford, 1727 Champa Street, Denver, Colo., controls the rights for the use of the waters of this stream, one of the largest tributaries of the Gunnison River, in Gunnison County, Colo. Rights for storage in Taylor Park, Mr. Sandford states, have been secured aggregating capacity of 4,000,000,000 cubic feet. The fall in the river aggregates 100 feet per mile for a distance of 12 miles, and all of this can be made available by erection of dam at the head of Taylor River Cañon, which is a gorge of vertical quartzite and limestone walls about 100 feet wide at river bed; the dam could be raised to a height of 125 feet. The power output and its cost have not been reported on, but this is one of the largest hydro-electric propositions of that section, probably representing 40,000 horse power, and the cost should be economical. The site is 40 miles from Leadville, 85 from Cripple Creek and Colorado Springs, and 125 miles from Denver.

11. CACHE LA POUDRE. In Larimer County, 8 miles from Fort Collins, 90 feet fall can be utilized (without dam construction) from Poudre Valley Ditch, controlled by the Poudre Valley Res. Co., Mr. O. J. Blandin, president, at Eaton, Colo. Mr. Blandin advises that 900 horse power can be developed in a very economical way and market profitably at Fort Collins, Colo.

GEORGIA.

12. ETOWAH RIVER. I am advised by Mr. R. L. West, superintendent, Southern Tel. & Tel. Co., Atlanta, Ga., that he controls a power site in Barton County, 14 miles from Rome, Ga., where a 30-foot dam 600 feet long can be placed in rock location and create 32 feet fall, giving an output of 3,000 horse power, all of which could be sold at Rome. This appears to be a promising opportunity, but I have not seen engineer's report covering it.

13. BROAD RIVER. The Anthony Shoals Power Co., Mr. J. H. Fitzpatrick, president, Augusta, Ga., control a site on Broad River in Wilkes and Elbert Counties, 17 miles from Elberton, Ga. This project has received considerable investigation by engineers. Anthony Shoals, Broad River, are about a mile long and represent a fall of 55 feet, the river being 800 feet wide; the last development programme I have heard of contemplates a 70-foot high dam 1,450 feet long, giving a head of 85 feet. The location is alluvial in part; the Broad River is subject to flood rises of some magnitude. This last proposition is to develop 13,000 horse power, the current being transmitted to Augusta, Ga., 50 miles.

14. OCMULGEE RIVER. At the Lamar shoals, about 4 miles from Flovilla, Ga., and 3 miles from the main line of the Southern Ry. I am advised by Mr. Walter D. Lamar, of Macon, Ga., who controls this site, that a 20-foot high dam will secure 45 feet of fall, the water being diverted ¼ mile. The flow is about 1,000 second feet, and under these conditions some 3,500 horse power could be developed. I have not seen an engineer's report nor any estimate of development cost. The current can all be sold in Macon, Ga.

15. AMICALOLA RIVER. On this tributary of the Etowah River, at a point known as Heard's Shoals, is a promising power site controlled by Mr. S. D. Pickett, president, Albany Power & Mfg. Co., of Atlanta, Ga. Heard's Shoals are in Dawson County, Ga., within 8 miles of the great Georgia marble quarries in Pickens County. The site is within a few miles of the main line of the A. K. & M. R. R. This project has been reported on; according to the report a 50-foot high dam 200 feet long can be placed in rock location, and by 2-mile diversion a fall of 205 feet can be secured and 5,000 10-hour horse power developed. The cost is not given, but will probably be $100 per horse power. It is 22 miles from Gainesville, Ga., 45 from Atlanta.

IDAHO.

16. ELK CREEK. In Nez Perces County, Mr. B. E. Bush, of Moscow, Ida., controls a 300-foot fall power site which can be developed, without dam construction, by diversion of flow from basalt-rock creek bed in a flume or pipe line. Mr. Bush advises that 2,000 horse power can be developed very economically, and that the product can be marketed at Moscow, 40 miles from the site. This is in the center of the new wheat belt and in the North Idaho white-pine region. I am advised that a railroad is being constructed from Palouse City to this site.

17. SNAKE RIVER. The Shoshone Falls site in Cassia County is 4 miles from the town of Twin Falls. This is one of the several important undeveloped powers of the Snake River, representing a fall of 130 feet and allowing of a development exceeding 20,000 horse power. The dam, if any is needed, will be only a few feet high, the diversion short, and the cost of development therefore low. However, the only available market for such an output is at Salt Lake City, 200 miles, and the transmission problem and cost is the feature. The site is controlled by the Shoshone Power Co., Mr. Francis M. Lyman, president, Salt Lake City, Utah.

ILLINOIS.

18. ROCK RIVER. At Grand Detour, Ill., the river makes a large bend; the flow can be diverted across the ½-mile-wide peninsula and a fall of 15 feet can

be secured with a 12-foot high dam. The available flow here is 1,250 second feet, the power output 1,500 horse power. This site is owned by Mr. S. B. Newbury, of the Sandusky Portland Cement Co., Sandusky, Ohio, who acquired it originally for the purpose of furnishing electric power to a cement plant now nearing completion at Grand Detour, but this plan, I understand, is not now to be carried out. The current can be sold in Dixon, Ill., 6 miles, and at Sterling, Ili., 18 miles distant. A report has been made on this project by Mr. L. L. Wheeler, U. S. assistant engineer, stationed at Sterling, Ill.

19. ROCK RIVER. Another site is found some 50 miles below the one above mentioned, near Lyndon, Ill., the flow here being about 2,000 second feet, with an available dam site giving 10 feet fall; it is controlled by the Morrison Gas & Electric Co., Mr. Harvey S. Green, proprietor, Morrison, Ill., which latter point, 15 miles from the power site, is the market for the current. Both these Rock River projects are authorized by Congressional act, the river being navigable and under control of the War Department.

INDIANA.

20. BLUE RIVER. In Harrison County, 9 miles from Croydon, Ind., is a power site of 20-foot fall and an output of 1,000 horse power. It is controlled by Mr. Wm. Rothrock, of White Cloud Mills, at White Cloud, Ind. Surveys have been made but report and estimate have not been submitted.

INDIAN TERRITORY.

21. GRAND RIVER. At Flower Creek, near Fort Gibson, I. T., a dam 45 feet high and 450 feet long will create a head of 30 feet and a development of 7,500 horse power at a cost of about $75 per horse power. The current would be transmitted to Muskogee, I. T., now of 25,000 inhabitants, where it can all be sold at good rates. A contract can be made with the city for water supply from this dam, the present service being taken from the Arkansas River (the Grand empties into the Arkansas near Muskogee) which is very unsatisfactory on account of the constantly turbid condition of the water. Muskogee is 12 miles from the power site; the Frisco R. R. line passes the proposed dam location. This project is one of the most promising in that section of country, and with some storage provisions can be enlarged. Muskogee is growing very rapidly; five trunk railroads now center there and others are projected, while provisions have been made in the last River and Harbor Act to improve the Arkansas navigation channed from Fort Smith, 80 miles below, to Muskogee. Mr. C. N. Haskell, president of the Indianola Construction Co., Muskogee, I. T., controls this project. Report has been made by the author.

22. GRAND RIVER. At Carrie Island, some 26 miles from Muskogee, is a second power site where the river is divided into two channels by an island, and a fall of 40 feet can be obtained yielding an output of 10,000 horse power. This output could be taken to Fort Smith, Ark., 75 miles, and find profitable market. Mr. C. N. Haskell, of Muskogee, I. T., also controls this site, which was reported on by the author.

23. BLUE RIVER. Near Belton a succession of falls and rapids can be utilized by economical dam construction in rock location so as to give a head of 40 feet and an output of about 1,000 horse power at a cost of $80, which can be marketed at Tishomingo, I. T., 10 miles. Mr. W. C. Wells, of Tisho-

mingo, I. T., engaged the author to report on this project two years ago; it is yet undeveloped.

24. PENNINGTON RIVER. Near Tishomingo, I. T., a fall of 123 feet can be obtained by constructing a dam 8 feet high and 100 feet long, on rock, and diverting the flow in flume and pipe line 3½ miles, developing 1,000 horse power at a cost of $100 delivered to Tishomingo, I. T., 3 miles from the power house. Tishomingo is one of the growing cities of the Territory, the capital of the Chickasaws, has large marble quarries and is in the cotton belt, with two railroads. The power is controlled by Mr. C. B. Burrows, president, American National Bank of that city. The author has prepared plans and rendered report on the project.

25. ILLINOIS RIVER. Near Tahlequah, I. T., is a power site controlled by the Illinois River Light & Power Co., Mr. Fr. R. Lewis, president, Tahlequah, I. T., where a fall of 30 feet can be secured by a dam 34 feet high and 175 feet long, on rock bed, the power station to be arranged in the interior of the dam. The output here will be 1,500 horse power at a cost of $75, and all the current can be marketed at Tahlequah, 6 miles distant. This town, like Tishomingo, is rapidly growing; it is in the cotton belt and a region of large hardwood timber tracts. The author has rendered report on the project.

IOWA.

26. CEDAR RIVER. Not far from the mouth of this river there is an opportunity to gain a fall of 90 feet by diversion across a peninsula, by tunnel and open canal, of the Cedar River flow into the Mississippi; this would yield a development of some 10,000 horse power, the market for which would be at Muskatine, Ia., 8 miles, Davenport, Ia., 25 miles. Mr. E. B. Downer, of Muskatine, Ia., controls this project and has supplied these data.

MICHIGAN.

27. MANISTEE RIVER. The flow is 1,500 cubic second feet, this river being noted for constancy on account of drainage-area conditions guaranteeing a very high ground-storage capacity; it is not subject to floods. The river bed is alluvial; there are two sites, of 45 and 68-feet fall; an output capacity of 14,000 horse power can be developed at a cost of about $50 per horse power. The market for the current is at Grand Rapids, 100 miles; Muskegon, 75; Ludington, 30; Manistee, 22; Traverse City, 25; Cadillac, 15 miles, and other points. The property is owned by Mr. J. N. Salling, Manistee, Mich. Reported on by H. von Schon.

28. AU SABLE RIVER. The flow is 1,200 cubic second feet, the drainage-area characteristics being similar to those of the Manistee, both streams rising on the ridge in the center of the lower peninsula of Michigan; the formation is of deep drift with large ground storage and several lakes; the river has no flood rise. Several dam sites are available with 20 to 38 feet fall; the capacity of those from Flatrock down is about 13,000 horse power. The development will cost $65 per horse power. Market is at Au Sable and Osceola, 20 miles, and Bay City and Saginaw, 60 miles. The property is owned by H. M. Loud Sons Co., of Au Sable, Mich. Report has been made by H. von Schon.

29. THUNDER BAY RIVER. Flow is about 600 cubic second feet and subject to normal fluctuation. In the lower reach rock comes to surface and ground

storage is not as good as on Manistee and Au Sable, but there are several reservoir opportunities. Two power sites have been improved, but several others remain available—one of 40 and two of 25 and 30-feet fall respectively. The first is in rock location, the others in alluvial, chiefly of gravel and clay. Output capacity of these three is about 4,000 horse power, which can be developed at a cost of about $60 per horse power. The market is in Alpena, 20 miles. The property is controlled by the Fletcher Paper Co., of Alpena, Mich. H. von Schon has made surveys.

30. MONTREAL RIVER, Upper Peninsula. Available flow, utilizing three reservoir sites, is about 100 second feet, and a fall of 110 feet can be concentrated at a point ½ mile below the falls by diverting the flow in a pressure line. The output is reported to be 1,000 horse power at a cost of $110 per horse power. Market is at Ironwood and Bessemer, 10 and 18 miles. Property is controlled by Mr. E. D. Nelson, president, First National Bank, Ironwood, Mich., who also owns the Ironwood light, water and street railway plants and the electric line from Ironwood to Bessemer. The project has been reported on by Mr. F. A. Cokefair, C. E., of Duluth, Minn.

31. MENOMINEE RIVER. At the Grand Rapids, with a drainage area of 3,800 square miles, flow of 2,000 second feet, and fall of 27 feet. The power development includes a short diversion canal and will realize about 5,000 horse power at a cost of $60, which can be marketed at Menominee, Mich., and Marinette, Wis., 15 miles. Mr. Wm. Holmes, of Menominee, Mich., controls the site.

MINNESOTA.

32. MISSISSIPPI RIVER. Near St. Cloud, Minn., a fall of 23 feet can be concentrated and 10,000 horse power developed. The market is at Minneapolis, Minn., 53 miles; the site is controlled by Mr. E. F. Moore, of St. Cloud, Minn.

33. CROW WING RIVER. A fall of 22 feet and an output of 1,500 horse power at a cost of $80 per horse power can be developed 9 miles from Brainerd, Minn., which would be the market. The site is controlled by the Minnesota Water Works Co., Mr. Judd Wright, superintendent.

34. CANNON RIVER. At Cannon Falls a head of 40 feet can be secured and an output of 800 horse power developed at a cost of $60; the current can be marketed at Cannon Falls, two miles from the power site. The power is controlled by the Cannon Falls Light & Power Co., Mr. T. T. Comstock, Kenyon, Minn., manager. H. von Schon has reported on the project.

NEBRASKA.

35. Several large hydro-electric projects are being promoted with a view of supplying current to Omaha, which appears to be a very attractive market on account of the high price of fuel and the large amount of power used in packing houses, light, and traction plants. On the PLATTE in western half of Sec. 29, Town 17 N. R. 4 East, it is proposed to construct a diversion weir and head works and to locate from that point a 25-mile long open canal to carry 1,800 second feet; the head will be 125 feet and the output 18,000 horse power. Several large storage reservoirs are contemplated, and the service is to be restricted to 12 hours per day, resulting in the delivery of about 30,000 horse power for this period. Omaha is 35 miles from the proposed power house. The estimate of this development as prepared by engineers is $3,500,000. The

Fremont Canal and Power Co., of Fremont, Nebr., are organized to exploit this project, Mr. L. D. Richards, of that city, being the principal party in interest.

NORTH CAROLINA.

36. CATAWBA RIVER. Three miles north of Hickory, N. C., is the Thornton power site, owned by Col. M. E. Thornton, of Hickory, N. C., with a fall of 26 feet, and immediately above are the Horseford Shoals with a fall of 44 feet, controlled by the Southern Power Co. A consolidated development of these two will give an output exceeding 10,000 horse power. This power can be developed in stages suited to the market; there is now a demand for about 3,000 horse power. The conditions quoted are as furnished to me by the owner of the site; I have not seen an engineer's report.

37. CATAWBA RIVER. On the same stream, 15 miles from Charlotte, N. C., at Cowan's Ford, a fall of 30 feet can be secured by constructing a dam 22 feet high and diverting the flow for ¼ mile; 3,000 horse power can be developed and sold at Charlotte, N. C. The site is controlled by Mr. E. D. Latta, president, Charlotte Cons. Construction Co., Charlotte, N. C. The above data were furnished to me by Mr. Latta; I do not believe any engineer's report has been made.

38. LITTLE TENNESSEE RIVER. Near the Tennessee State line, the Craggy Lumber Co., J. S. Bailey & Co., of Swannonoa, N. C., Mr. S. F. Chapman, manager, own some 10 miles along the river, in which reach occurs a fall of about 225 feet, which can be developed in two sites: at the State line by a dam 127 feet high and 498 feet long, in rock location, and 6 miles lower down a dam 100 feet high and 500 feet long, also in rock. This project has received considerable attention and I quote from engineer's report the available flow at 1,780 second feet and the corresponding output 32,000 horse power, which it is estimated can be developed for $75 per horse power. The market for this must be found in Atlanta, Ga., 120 miles distant.

OHIO.

39. SANDUSKY RIVER. The consolidation and modern development of several old mill properties at Fremont, Ohio, forms an attractive hydro-electric project. What was formerly the Creager mill at the city limits, the Hein & Brown mill just above, and the Tucker mill, now in commission, representing an aggregate fall of 40 feet, can be economically developed by two dams in rock location of 18 and 22 feet height respectively, each 300 feet long. The old Creager mill, a substantial stone building, can be re-utilized. This will yield an output of 2,000 horse power, all of which can be remuneratively served to industries now operating in Fremont, using over 3,500 horse power, or to the Lake Shore Electric Railway, operating lines from this point to Toledo, Cleveland, and Tiffin. The project is being promoted by the Fremont Power & Light Co., Mr. D. B. Love, secretary, at Fremont, Ohio. The author has made report on it.

40. CUYAHOGA RIVER, at the Falls. The available flow is said to be 200 second feet, subject to some lower stages and high-flood flow. The falls represent a total drop of some 150 feet, a considerable portion of which is now developed at three successive sites; these improvements are of the old type and can be economically consolidated in one development, with 60 feet fall, of

1,000 horse-power output. The cost of a plant would be low, as the river passes down a rock gorge 100 feet wide; probably it would not exceed $50 per horse power. The market for current is at the Falls. The property is controlled by Mr. C. M. Walsh, president, Hollow Staybolt Mfg. Co., Cuyahoga Falls, Ohio. No report has been made as yet.

41. AUGLAIZE RIVER. Near Defiance, Ohio, is a drainage area of about 2,500 square miles of medium ground-storage capacity, available flow probably 1,000 second feet subject to some lower stages, and a flood discharge of 5,000 second feet. A fall of 20 feet can be obtained with 13-foot high dam and one-mile diversion canal, yielding an output of 1,600 horse power at a cost of probably $80 per horse power. The market is at Defiance, 3 miles from the power site which is controlled by the Auglaize River Power Co., Hon. T. T. Ansberry, Defiance, Ohio.

42. MAUMEE RIVER. At Perrysburg, Ohio, the river's drainage area comprises 6,500 square miles; the low flow is about 700 feet per second; flood discharge is high. A water power was developed just below Waterville, Ohio, under a special Legislative charter and operated until about 1887 but has since been idle. The dam, which was only 5 feet high, has disappeared; the canal which diverted the flow for about 4 miles remains in good condition. The river bed is in rock ledge; a head of 22 feet can be secured and an output of about 1,300 horse power. The market is at Perrysburg and Maumee, at the power site, or at Toledo, 7 miles distant. The opportunity is controlled by P. M. Puhl, ot Maumee, Ohio. H. von Schon has made surveys.

PENNSYLVANIA.

43. DELAWARE RIVER. The Walpack Bend is an oxbow in which the fall is 20 feet, and this can be increased to 40 feet by a 25-foot high dam above, the water being diverted across the peninsula through a tunnel about ¼ mile long. An output of 10,000 horse power is said to be available. This site is within 25 miles of half a dozen good sized cities in Pennsylvania and New Jersey, and only about 60 miles from New York. It is controlled by Mr. E. F. Peters, of Bushkill, Pike Co., Pa.

44. BUSHKILL. The noted Bushkill Falls have a vertical drop of 300 feet. This is about 2 miles from the power just described and is likely to be capable of a 4,000 horse-power development at an exceedingly low cost. This also is controlled by Mr. Peters and should be developed together with the Walpack Bend power, the two representing one of the most attractive remaining opportunities in that section of the country.

SOUTH CAROLINA.

45. BLACK CREEK. Near Florence, S. C., a fall of 28 feet can be obtained and an output of 3,000 horse power, the market for which is at Florence, 3 miles, and Darlington, S. C., 8 miles distant. Florence is division point of three railroad lines and is a growing town, the region being one of the most fertile in the Pine State. The opportunity is being promoted by the Black Creek Power Co., represented by Mr. S. S. Ingman, of Florence, S. C. I understand an engineer's report has been secured; these data were furnished me by Mr. Ingman.

46. BROAD RIVER. In Fairfield County a power opportunity is offered of 31-feet fall. The dam would be 33 feet high and 900 feet long; the power sta-

tion could be in its interior. The project has received considerable engineering attention and a report has been made, from which these data are quoted. The flow is accepted at 2,500 second feet and the output at 6,000 horse power, which can be marketed at Columbia, S. C., 16 miles distant. The Central Carolina Power Co. controls the situation and Mr. A. E. Gonzales, president of the State Company, at Columbia, S. C., has furnished this information.

47. KEOWEE RIVER. A tributary of the Savannah River, in Oconee County, about 12 miles N. E. from Seneca, S. C., affords an opportunity to develop a 36-foot fall by constructing a dam 34 feet high and 250 feet long on rock ledge. Mr. Jas. Thompson, of Walhalla, S. C., owns the site and has placed at my disposal an engineer's report which credits the project with an output of 1,800 horse power, to be developed at a cost of about $100 per horse power. The market is at Seneca, S. C.

WISCONSIN.

48. WISCONSIN RIVER. There are several undeveloped powers of large capacity. At Mosinee the Little Bull Rapids create a fall of 20 feet; the flow is 3,000 second feet and the output about 5,000 horse power, which can be developed at a cost of $80. This power should be used for pulp grinding, as the pulp-wood supply is ample and transportation facilities good. The Joseph Desert Lumber Co., of Mosinee, Wis., control the power site. H. von Schon has made report on it.

49. CHIPPEWA RIVER. At Brunette Falls. The contributary drainage area comprises 5,000 square miles; the vertical drop is 10 feet and a fall of 35 feet can be secured very economically as the rock gorge is but 75 feet wide; 8,000 horse power can be developed at a cost of $65 per horse power, the market being at Chippewa Falls, 21 miles, Eau Claire, 31 miles; it is 90 miles to Minneapolis and St. Paul. The falls are controlled by the Cornell Land & Power Co., Chas. McArthur, manager, at Eau Claire, Wis.

This list presents no powers in New England and the Eastern States nor on the Pacific Coast where, as a matter of fact, the largest number of remaining opportunities are to be found; but while I have record and data of many, the line must be drawn somewhere. However, it would be unfair to close without mentioning the fact that Canada has within her borders undeveloped water-power resources exceeding those on the American side, though the best are yet on the outskirts of civilization and must wait for the pioneer and the track. I will mention one.

50. ONTARIO. MAITLAND RIVER, in the Georgian Bay district. Some 3 miles from the city of Goderich the Maitland makes a double turn and thus is created a power opportunity with a 78-foot fall and 3,000 horse-power output. The river's flow is remarkably constant, not subject to floods; the development is economically feasible. Current would be marketed in Goderich, which is a flourishing city with good harbor on Lake Huron and Canadian Pacific & Grand Trunk Railway terminals. The city has voted to guarantee half of the necessary bond issue to develop this power, which is controlled by the Maitland River Power Company, Mr. J. T. Goldthorpe, manager, Goderich, Ont. The project has been examined and reported on by the author.

PROFIT MAKING IN SHOP AND FACTORY MANAGEMENT.

By C. U. Carpenter.

V. MINIMIZING THE TIME OF MACHINE-TOOL OPERATIONS.

Mr. Carpenter's series began in January, and the four articles successively presented discussed, first, the general methods of examining into the condition of any manufacturing business so as to discover the existence of waste and loss and to determine the "sticking points"; second, the nature and the working of the "committee system" of factory administration; third, the reorganization of the designing and drafting departments; fourth, the great importance and value of the tool-room as a source and spring of profitable methods. He now reaches the very center of production in the machine shop—the operation of the machine tools themselves. The present article traces the general conditions necessary for manufacturing at minimum cost. A following and supplementary paper in July will show how the tests determining "standard times" for machining and for assembling can be made, and how the times so fixed can be introduced into routine operation in the shop.—THE EDITORS.

TWO fundamental principles of cheap production lie hidden away amongst inefficient shop processes, bewildering disorder of shop conditions, and lax, inaccurate, and utterly misleading shop methods. They are of the greatest importance, and yet nine times out of ten a searching investigation will prove that little consideration has been given them in ordinary shop practice. They are so closely related that their simultaneous discussion is advisable. They are both essentially "time savers." These two principles are:

1.—The determination of "standard time" for each job, and its tabulation, introduction, and enforcement.

2.—The absolute elimination from the workman's routine of every duty but that of running his machine continuously and efficiently; the bringing to him of tools and stock for his next job before he is ready for it.

The first and possibly the more vital of the two is the determination of standard time upon each job—that is, the shortest space of time in which each job should be completed (including setting up), under normal conditions and with due regard to the fullest possibilities and capacity of the machine tool, the cutting tool, and the stock.

An appalling undertaking, this, in most shops, under existing conditions; appalling and seemingly impossible because of lack of knowledge as to the best shapes for cutting tools, the best methods of hardening and grinding, the results to be secured from the use of

high-speed steel cutting tools, the best methods that can and should be adopted by a skilled workman, the total ignorance of the capacity of the machine tools in the shop, and, worst of all, the lack of men skilled in the best methods for handling these cutting tools—men capable of doing the work and of seeing that the workmen do it.

It scarcely seems necessary to argue in favor of this determination of standard time; and yet many manufacturers seems to prefer to leave the question of rapidity of production to the foreman's judgment and skill alone. Their confidence, while perhaps amiable, is usually misplaced. No man with real shop experience will assert that the average foreman does, or in fact can, know the best results that can be secured in machining today, unless he has been afforded and *has accepted* exceptional opportunities for making thorough tests of a really scientific character—something that rarely happens. Even should a foreman possess this desirable knowledge, it is beyond the power of any one man to supervise properly any group of men, even though small, so that the high point of efficiency may be assuredly reached, and at the same time do the other work that usually falls to the foreman's lot.

Again, the use of high-speed steel for cutting tools is a development of recent years. Notwithstanding all that has been published on this subject, comparatively few shop foremen really know what the fullest possibilities of its use are, and fewer still ever force their departments to use it to its fullest efficiency even after its value has been recognized. In fact, there have been comparatively few tables ever published that show in a practical manner just what can be done with it. The machine-tool builders themselves, singularly enough, seem to be unable to give any positive, accurate advice as to the actual conditions of cutting speeds, feeds, and depths of cut under which their own tools can best operate, and even the makers of the tool steels do not provide tables of much practical use.

Nevertheless the work of such a man as F. W. Taylor, in his remarkably thorough and extremely valuable publication, "The Art of Cutting Metals," clearly shows the possibilities that lie in the use of these modern cutting tools—Messrs. Taylor and White being the discoverers of these possibilities, and Mr. Taylor himself leading the van in the application to practical use of these principles. This one work makes clear not only the great possibilities but also the great difficulties that originally lay in the path of the investigator. With all of these points in mind, it is simply "rot" to give heed for a moment to any claim of any shop man that his knowledge of this subject is at all exhaustive.

Standard times should be determined by *some one, some how.* Certainly no one can dispute the fact. Experiments and experience show that the good old plan, "depending on the foreman" for this determination, as mentioned above, gives results 40 to 60 per cent short of maximum efficiency. Inasmuch as your entire business is built upon and depends upon the cost of production—or, in its last analysis, simply "the time it takes each man to do his job of work," it is of *fundamental importance* that that standard time be first determined by methods that will ensure accuracy.

The second cardinal principle of cheap production stated at the outset was "the absolute elimination from the workman's routine of every duty but that of running his machine continuously and efficiently; the bringing to him of tools and stock for his next job *before he is ready for it.*"

The machine hand, assembler, or other worker must be forced to concentrate his skill and attention upon his own work and that work alone, making it impossible for him to waste his time (and thus the employer's money) upon work he should not do. Consider for a moment the many things that a machine hand, for example, will ordinarily do other than operate his particular tool, and then give a moment's thought to analyzing the result. The worst "time wasters" can be classified somewhat as follows:

(a) Running to the supply room for stock for a new job, Result, the machine tool is shut down.

(b) Getting tools, clamps, etc., from the tool room for a new job. Result, the machine tool is shut down.

(c) Grinding his own tools (and very badly at that). Result, the machine is shut down.

(d) Excessive time in "setting up" a job, due to lack of proper instruction, or to a tendency to "soldier" because of lack of supervision. Result, the machine is shut down.

(e) To these add the further tremendous loss of output because the workman fails to use the proper—the very best—cutting speeds, feeds, and depth of cuts, through either lack of knowledge or lack of supervision, and you have a combination that cuts the output of the ordinary shop far below what it should be.

If your shop is running under ordinary foremanship supervision, with no thorough method for bringing to the workman his stock; for providing him with tools for the next job before he is ready for it; with no method of instructing him what to do and how to do it, and no thorough way of comparing his output with what it should be

according to the best standards of today, (mark me! not your foreman's standards)—then you can make up your mind that your output is far too low according to the best standards of production.

You may imagine that "carefully calculated" piece-work rates will protect you; but if your piece-work rates have to allow for the conditions stated just above, you are deceiving yourself grossly as to the possibilities of your output.

The important consideration is time! time! *Time of the workman running his tool*—that is the vital point. Every minute counts for profit if this tool is operating continuously and efficiently, for loss if it operates under the nullifying influences detailed above.

Consider for a moment! Your entire factory investment—building, power plant, transmission plant, all probably built and selected with great care and expenditure of money—is simply to care for and operate the separate units of machine tools, or to properly house your assembling spaces. Your investment in machine tools represents large sums. This vast expenditure is made with but one object in view—that of producing work and producing it as cheaply as possible. Calculate accurately your indirect charges of every character; proportion the total against each machine tool according to the "machine-rate" method of apportionment, and note carefully how large must be the rate per hour for each machine. This will be found to be an astonishingly large proportion of the labor rate per hour and will prove a good index of the great cost of lost time in the shop.

Is it not clear, then, that each machine tool should be, nay *must* be, brought to *as high a factor of operating efficiency* as possible? Is not your entire investment made with that one end in view? Does it pay to have the efficiency of any collection of these units reduced 15 per cent to 25 per cent by the existence of such shop methods as those detailed, by which the men operating the machines are actually compelled to shut them down to hunt up their next job, to collect their tools, to grind their tools, and do many things that should be done for them? Can you afford to suffer an even heavier reduction in efficiency due to lack of knowledge of the "best time for each job?"

The importance of these points can be further emphasized by considering that all such delays, which in their total represent a large amount, directly affect cost and profits, output, indirect expense of every description, quick movement of stock, and hence ultimately the amount of working capital needed in the business, and the possibilities of quicker deliveries, with a resultant direct effect upon the sales department and customers. Indeed, aside from the question of costs and profits, nothing is more important to the separate mem-

bers of a company, from the executives with their financial problems, through the sales department with their selling problems, to the harassed factory manager, than the quick movement of stock.

The reason for the continual absorption of working capital into machinery or stock that worries many a financial officer, or for deliveries so delayed as to affect seriously the efficiency of the selling organization, or for excessive and unreasonable and possibly unexpected costs that seem and, in fact, are out of reason—the reason for all lies hidden away back in the shop processes and methods. It crops out at the individual lathe, planer, shaper or assembling bench, and then only to the keen experienced eye. The workmen busy? Surely. Look at them hustling! But—see that group around the tool-supply window waiting for tools? How many are waiting at the tool grinders to grind their own tools each in his own "individual" manner? There is a mechanic who has taken twenty minutes to "set up" his job instead of ten. Then pause and wonder how in the world any one or two or more foremen can be sure that the men now operating the machines are using proper speeds and feeds and getting the most out of the machine and the tool.

In fact, the causes for all these serious troubles are located so far back toward the fundamentals of production—the individual units affording the causes are so seemingly unimportant, and such is the difficulty of recognizing these conditions, buried as they are in a busy shop—that they are overlooked or ignored.

As a general proposition, the greater the difficulty of solving such problems the more important and necessary becomes that solution, simply for the reason that in this you are dealing with human elements to whom is given the opportunity of slowing up in production solely because of that very difficulty that lies within the problem itself and its solution. And yet so fundamental and vital is their importance that they cannot be ignored.

THE STARTING POINT FOR STANDARD-TIME DETERMINATION.

Investigation of Existing Machinery.—Any plan for the introduction of proper methods for the determination of standard time and the elimination of wasted time must begin by an investigation of the existing shop machinery—an individual report upon each machine tool, especially touching upon the defects, and a recommendation as to what types should be purchased in the future to meet modern production requirements. This is a matter of great importance, but often overlooked. Unless the needs of the shop in the way of modern machinery, designed to stand up under the latest high-production requirements, are recognized and listed up at the beginning of the

introduction of any new plans, this important matter is liable to be lost sight of later, with the consequence that when the time for purchases of new machinery does come, the older inefficient types are clung to and the shop is further encumbered with old-style tools.

Nor is the question of securing a more rigid and efficient tool such a simple question as at first appears. Few machine-tool manufacturers are making an earnest attempt to place upon the market tools strong enough to meet the more severe requirements of today. Why? First because comparatively few have made tests of sufficient scientific worth to determine where the points of greatest weakness really are and how to strengthen them properly. Second—there is the money tied up in old patterns, old stock in the factory bins, in machines going through the pocesses of manufacturing, and finally in finished machine tools carried in the sales rooms. Changes of a radical character would prove a serious matter under such conditions. And, again, the demand of the manufacturer for better and heavier tools has not been urgent enough to force the machine-tool builder into the tremendous trouble that a thorough redesigning of the older types would surely cause. Therefore the latest product of a machine-tool manufacturer is not necessarily adapted to the methods of production that I am advocating.

Greater driving power is usually the first requirement. Accurate tests have shown that modern lathes, for instance, should have fully double the driving power usually contemplated in their design. This is a point that must be considered carefully. Of course a proper increase in driving power of a lathe, for example, means wider cones, heavier bearings, and stronger heads. Immediately there follows the question of the rigidity of the bed. It is at once apparent that this is a very important point, and yet too little attention has been paid to the design of bed best suited for withstanding the strains and stresses due to the use of new high-speed cutting tools. Solidity is very necessary. The consideration of the need of strength and rigidity should certainly be applied to the tail stock. Slide rests and tool holders should be simple and strong. The tool must be held rigidly under all conditions. The tool posts should be set down lower than is customary in every-day practice. Under modern conditions much greater feeding power is needed.

But however certain we may be that defects in machine tools have a direct effect upon the rate of production and the cost of the product, existing conditions may prevent purchase of new tools. Inasmuch as I have been through the mill several times with run-down concerns, I appreciate fully the fact that most manufacturers are obliged,

through sheer financial stress, to ignore any scheme, no matter how promising, that involves at the outset a thorough replacement of the existing machinery with the most modern types, even though it can be demonstrated that the latter are 50 per cent more efficient.

The practical question that confronts many a manager is: "What on earth can I accomplish with my ***present old*** 'rattle traps' of machine tools? I couldn't buy gold dollars for 98 cents if I had to pay cash, much less spend thousands for replacing my present machinery. *I must first make good with what I have.* After we are on firm ground we'll talk about stronger and better machine tools."

True! Very true! A viewpoint very often overlooked by the manager, or by the man who has this work in charge but doesn't have to produce the dollars to "keep the old ship afloat." This latter situation, which is a stern actuality with many a man who is eager to improve conditions, is all compelling and must give shape to the preliminary methods of procedure. This I shall try to keep in mind.

Granting, however, the hard fact that many concerns are obliged first to dig out the problem, using their existing facilities, it is of all the greater importance that two reports relative to machine tools be made out:

First, a report showing what heavier, stiffer, and more efficient types of machines should be substituted for existing types when the proper time comes.

Second, a full report upon each and every machine tool in the shop, showing its points of weakness and its limitations in cutting speeds, feeds, and depth of cuts; how it can be strengthened; a description of the kind of work that should be done on it; a record of best times on jobs; a full statement of the best machine tool to substitute for it, and a clear-cut comparison of possible production by the use of the latter machines.

I warn you again that unless this be done systematically *at the start,* it probably never will be done; then as time goes on you will find yourself burdened with many a newly purchased machine tool just as weak and inefficient as the older one it replaces.

In considering the problems of increasing production in any particular shop, we find therefore that they become problems of devising methods and making tests upon the supposition that existing machines and facilities must be used in regular production—that, however advantageous the later types of tools, the important question of lowering costs must be considered on the basing of developing to the uttermost the efficiency of the present machinery. We must therefore keep in mind these points in the building up of our system. The

great importance of gathering all our data systematically and of using them scientifically cannot be too strongly insisted upon.

Possibilities Underlying the Use of High-Speed Steel.

Closely linked with the study of the design, character, and remodelling of the existing machine tools, is the second great step in the betterment of machine processes—the use of high-speed steel cutting tools.

The possibilities underlying their introduction and full employment have been thoroughly discussed by other writers and proven again and again in every-day shop practice where thorough methods have been adopted. It is sufficient to say that the increase in production over that secured through the use of the older carbon steels may be expected to reach from 40 per cent to 85 per cent (depending upon the character of the metal being cut) if the machine tools are in proper condition to withstand the strains of the increased cutting speeds, feeds, and cuts. If the shop under consideration is in a run-down condition, and there has been lack of system in shop processes as well as lack of efficiency in production methods, a much greater increase than 90 per cent may reasonably be expected. I have noted myself records of over 200 per cent increase in efficiency and output, and have been shown records in a number of cases that exceed 300 per cent. Of course to anticipate such large increases in all cases would be foolish, but there are many cases today where such results are well within the range of possibility. Such a prize is well worth fighting for.

The Determination of a Proper and a Standard Shape for Cutting Tools, the Supply of a Sufficient Quantity to Avoid Lost Time.—This is the first point of attack. Before another step is taken these standard tool shapes *must be determined* and *must be rigidly adhered to*. The old tool dresser, who is in all probability totally ignorant of the proper shapes of tools as determined by scientific experiments, and probably stubbornly sticking to his "home-made" knowledge of hardening the modern tool steels, must be eliminated. The practice of allowing a hundred workmen to grind their tools in a hundred different ways must positively be stopped.

In place of these haphazard, inefficient methods must be substituted those that will lead to the adoption of standards proven by experiments and experience to be efficient, and these must be adhered to without deviation.

In view of the differing opinions of factory men upon the subject of proper shape of tools, it is fortunate that we can refer to the results of and deductions from the experiments of Dr. Nicholson, and

later, and indeed especially, to those of Mr. F. W. Taylor of Philadelphia, as guides which can safely be followed. The latter tests of Mr. Taylor are especially exhaustive and convincing. The results of the tests performed in a modest way under my direction are confirmed by Mr. Taylor's data. The limits of this article prevent any lengthy discussion of the many important points to be observed; they must be skeletonized only.

1.—In determining the most effective shape for any tool, such as for instance a lathe tool, careful consideration must be given to the fact that limitations may have to be placed upon the shape which would provide the greatest cutting efficiency, by the necessity of considering the difficulty and cost of forging and grinding. These costs may prove such as to require a modification of the type which *per se* would be the most efficient.

2.—The dynamometer tests by Dr. Nicholson demonstrated the fact that a tool with lip angle of 54 degrees (cutting angle 60 degrees, clearance 6 degrees) would remove soft steel at a low degree of pressure. Such an acute angle, however, can hardly be considered for commercial use, because of the danger of crumbling. He established the fact, however, that we should generally adopt the sharpest angle of cutting tool that would not crumble under the strain of working conditions. His tests showed that on medium cast iron cutting angles should be 76 to 80 degrees (with clearance of 6 degrees) and consequently their lip angle should be about 70 to 74 degrees. His tests upon soft steel were not conclusive because of working conditions, but the tests he made indicate that a cutting angle of about 70 degrees (lip angle 64 to 65 degrees) lasted the longest time in rapid cutting.

Mr. F. W. Taylor's tests show that tools for cutting softer steels should have a clearance angle of 6 degrees, back slope of 8 degrees, side slope of 22 degrees, or a lip angle of 61 degrees. For cutting cast iron and harder steel the tool should have clearance angle of 6 degrees, back slope of 8 degrees, side slope 14 degrees, or a lip angle of 68 degrees. On harder steel a clearance angle of 6 degrees, back slope of 5 degrees, side slope 9 degrees, or a lip angle of 74 degrees is recommended. On chilled iron a lip angle of 86 to 90 degrees is recommended.

Great care must be exercised to see that the point of the tool is blunt to such a degree that crumbling cannot occur. The round-nose tool with a large radius of curvature has been adopted by me as the best of its type, although straight broad-nosed tools can at times be used to good effect. As regards the question of side slope vs. back slope I favor steep side slope, though guarding to the utmost possible

against gouging into the work. A combination of these two can be secured that will produce good results.

This question of shapes of tools must be thoroughly thrashed out and settled by the expert and the committee before another step is taken. Decide upon your standard types. But whatever types are decided upon, by all means adopt a few set rules in regard to tools, and stick to them.

First. Reduce your sizes of tools and the types of tool steel to a minimum.

Second. Adopt standard shapes and then don't change them.

Third. Stock up your tool-supply room with plenty of small tools. Keep the workmen supplied.

Forging.—The final standard shapes of tools having been decided upon, then take up the important question of the proper forging of the tools. Here is where vigilance should begin. In the first place, limit gauges will pay. Your tools must be forged to the correct shape and in such a manner as to reduce the preliminary grinding to a minimum. The shapes must be considered with care so as to provide for cheap and effective tool grinding after the tool begins its life of usefulness. Naturally the conclusions reached in the consideration of standard shapes will influence very largely the methods of forging. Do not run the risk of starting cracks in your tool steel by nicking it and breaking the pieces off cold. In heating the tool do it slowly so that the heat will have ample time to penetrate the entire bar. Unless this is done cracks may develop. Bring it up to a light yellow.

Methods of Hardening.—Considering the large volume of good information now available as to the best methods of hardening high-speed tool steel, it is strange to note how often we find the toolsmiths adhering to plans of their own.

It is of great importance that your toolsmiths should be given to understand that any adherence to the old "color" ideas in the processes of hardening must be absolutely abandoned, and that the newer methods of hardening recommended by the makers of tool steel must be absolutely followed. At one time the methods described by the makers were unnecessarily complicated, in order to throw a certain degree of mystery around the processes, but of late the tendency has been toward a decided simplification.

It is highly desirable that the number of grades of high-speed steel used in a shop be reduced to as low a number as possible—certainly not over two, and, if possible, one—and that a thorough standard method of hardening be adopted, and adhered to. Owing

to the tendency of the ordinary toolsmith to slip back into his old slipshod ways, it is important that some accurate record of his hardening processes and some check be kept upon him, especially during the period when practical methods of hardening are being introduced and thoroughly standardized. The record need be only a simple one, but must be sufficient to enable you to trace unerringly any defects appearing in the tools due to bad process of hardening, and to center the responsibility for these mistakes upon the toolsmith responsible for them.

I therefore suggest the following form for keeping hardening and tempering records:—

HARDENING RECORDS.

Date _____

Tools	Size	Quality of steel	Lot No.	Remarks

Hardening Heat Temperature.
Cooling Agents.
Tempering Heat Temperature.
Toolsmith. _____
If defective, Why? _____

FORM FOR HARDENING RECORDS.

The methods of hardening lathe, planer and boring tools are fully described by the makers. Generally the forged nose of the tool is placed in a well-burned-through coke or coal fire, and brought slowly to a white welding heat. This heat should be raised to a point where the nose begins to soften. Care should be taken to see that this heat extends over fully three-quarters of an inch of the nose. At this fusing heat, the white-hot part should be put immediately under the strongest and coldest air blast which is available, compressed air being the best to use. Under no circumstances must the tool be brought in contact with water while it is hot. It is probably preferable to harden

the white-hot nose of the tool in fish or lard oil until it grows moderately cool, and then to continue the cooling-off under a cold blast.

Mr. Taylor, in his description of the heat treatments, brings out the important feature that the nose of the tool should be heated *slowly* to a bright cherry red, so that the heat may penetrate to the center of the tool. From the bright cherry red up to the melting point, the tool should be heated as rapidly as possible in an intensely hot fire until the nose of the tool begins to soften. He urges very strongly the importance of using an intensely hot fire for the second period of heating.

The cooling of the tool should be done rapidly until it is below 1,550 degrees F. From this point it makes little difference whether it is cooled rapidly or slowly. Mr. Taylor advises the use of a bath in red-hot molten lead in bringing the tool down below a temperature of 1,550 degrees.

In his article on the "Art of Cutting Metals" he brings out the advantage of the second or low-heat treatment, which is obtained by re-heating the tool which has had the high-heat treatment to a temperature between 700 and 1,240 degrees F. Great care, however, must be used to see that the higher temperature is not exceeded, for should this happen the quality of the tool will be seriously affected.

For the heating of special form tools, milling cutters, etc., special methods are of course necessary, the use of the ordinary coke or coal fire being out of the question. Where a number of these parts are heated at a time, great care must be taken to see that they do not touch one another. Special furnaces should be used. These can now be purchased for a reasonable figure. In these furnaces the work can be properly suspended so that separate pieces will not come in contact with one another, and accurate control of the heating can be secured with the aid of a pyrometer.

Grinding of Tools.—As was pointed out under the heading of shapes of tools and forging, it is necessary to determine these shapes with care so that the cost of grinding the tools will not be excessive.

It seems hardly necessary to assert the importance of having all tools ground in one place and according to standard shapes. There are, however, a surprising number of shops still left in which the workmen are allowed to grind their own tools in their own way. Inasmuch as tests show that the shape to which a tool is ground will affect its efficiency to a very high degree, it is perfectly obvious that such a plan as allowing the workmen to grind their own tools is simply ruinous, to say nothing of the question of wasted time on the part of the workmen.

We must, of course, assume that under the heading of shape of tools the manufacturer has determined just what grinding angles should be adopted throughout. It is of much importance that these angles be rigidly adhered to, not only because they will prove the most efficient, but also because all the tabulations which any one may make up for any particular shop will be based upon these standard shapes and consequently any variation from these shapes will tend to vitiate the records and so annul the good points of the determination of standard time.

In my opinion, all grinding of tools should be done by automatic machines, so that all angles can be ground uniformly. If, however, this grinding is still to be done by hand, it is very important that you get a thoroughly skilled man and watch him with extreme care, especially at first, to see that he will adhere to your specifications for grinding angles. If you do not watch him, he is almost certain to slip back to methods of his own or to adopt those of other men in the shop. If this grinding is done by hand, then provide the tool grinder with proper templates and tables so that the possibility of mistakes will be eliminated as far as possible. Such is the importance of grinding these tools accurately, however, that an automatic machine grinder will be found almost necessary.

Overheating of the cutting tool during grinding is one of the greatest causes of deterioration of quality. Caution is generally impressed upon the people handling these tools, and it can not be urged upon them too strongly. Many a tool apparently in good condition has been ruined by overheating in the grinding operation. The tool should be moved continually. A cooling agent directly on the nose of the tool should always be used. Many makers of high-speed steel state that while grinding on a dry wheel may be done, at the same time *great care must be taken* to see that the tool *is not discolored, i. e., overheated.*

I concur in the statement of Mr. Taylor that on the average a lathe tool should be so operated that grinding would be required at the end of an hour and a half, going, of course, upon the presumption that the tool is of standard, high-grade quality. In many of the tests on which records have been presented and in the data which are always submitted by the high-speed steel manufacturers, we find a continual reference to the length of time a tool runs without regrinding. This, however, is of very little interest to the average manufacturer, as the question is not how long a tool may run without regrinding, but how much should a tool be forced so as to produce the most work with a minimum expense for grinding, keeping in

mind at all times that the crowding of the machine tool is the important consideration. The question of how long a tool may run without regrinding sinks into the background, especially if the grinding of a tool may be done in a scientific manner by automatic grinders.

The use of cooling agents, such as soda water, is highly desirable. An increase in production of 35 per cent on medium and soft steel can be secured through the use of a properly directed heavy stream of water.

Finally, let me urge the necessity of keeping a large supply of tools already ground up in the tool-supply room, so that, under no circumstances, will the workman be compelled to wait for his cutting tools. This is an important point and is often overlooked.

The Determination of Standard Time.

To sum up, then, the standard times for any shop depend upon the following:

1. The character and limitations of the existing machine tools.
2. The introduction and use of high-speed steel for cutting tools. This will include:—
   (a) The determination of the proper shapes for tools.
   (b) The provision for proper treatment of steel of this character in forging, hardening and grinding.
   (c) The determination of the best working conditions possible, such as the cooling agent, etc.
3. The securing of the maximum possibilities in cutting speeds. This includes:—
   (a) The careful consideration of tests already made and submitted by different investigators, giving of course due thought to the conditions existing at the time of the test.
   (b) The adaptation of these records to existing shop conditions and the making of thorough tests in the local shops under the limitations imposed by types of machine tools existing in the shop.
4. The collation of all production data upon a systematic plan and their arrangement so that they can be used.
   (a) The instruction of the foreman and the workman as to the results to be expected and how to secure them.
   (b) The insurance that the every-day production follows closely this standard of efficiency.

The first and second sections have been discussed in the present article. The third and fourth—that is, the fixing and the practical introduction of standard times—will be taken up and explained next month.

REINFORCED-CONCRETE STRUCTURES FOR MANUFACTURING PURPOSES.

By Leonard C. Wason.

The vast extension of the use of steel as a structural material has become so familiar to our observation that the wonder of it is overlooked. And now, closely associated with it and in part dependent upon it, comes another great phenomenon—the even more rapid rise of concrete-steel for all forms of construction. The peculiar advantages of this mode in stability, fireproofness, adaptiveness to design, and conformity to many of the requirements of manufacturing buildings, make it highly important to the industrial manager or owner who is contemplating the erection of new plant or extension of old. It is from this broad viewpoint that Mr. Wason considers the subject. Following articles in THE ENGINEERING MAGAZINE by specialists in this branch of engineering will discuss other phases.—THE EDITORS.

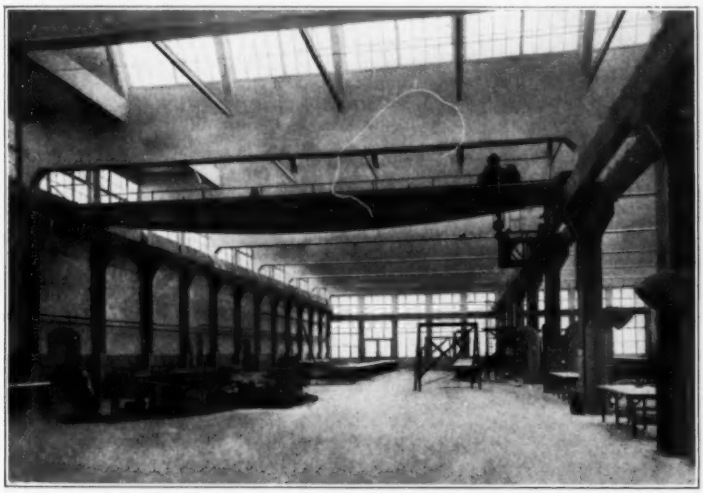
REINFORCED concrete is not a new building material. Twenty-five years ago, a number of large buildings, including some for manufacturing purposes, were built of reinforced concrete in and about San Francisco, and all these structures appeared among the buildings which most successfully withstood the earthquake and fire of 1906. The uses of concrete have been increasing and the variety of its applications have been widening ever since. Gradually its merits and advantages have gained general recognition, until within the last few years so many structures have been built as to attract almost universal attention. The comparative shortness of the time within which attention has thus been generally centered on this type of construction has led to an erroneous impression. The fact is, however, that the full test of time and trying out of the various types and applications through severe experience have today enabled it to hold a front rank as a building material, unquestioned by those who have had experience in its use, and commanding the confidence of all.

The general principles of design and construction have changed but little in these twenty-five years. There have been a number of changes in details dictated by the experience gained through use, which developed all the possibilities and demonstrated the few limitations of reinforced concrete, and changes also based upon the knowledge obtained by the large amount of experimental research in the laboratories of many technical schools upon the physical properties of the combination of steel and concrete; so that today designs can be as accurately made and results as confidently guaranteed as is possible with brick, stone, wood, or steel construction.

ABOVE, SPECTACLE SHOP OF AMERICAN OPTICAL CO., SOUTHBRIDGE, MASS. BELOW, COAL POCKETS AT HARTFORD, CONN.

Reinforced-concrete construction, by the Aberthaw Construction Co., Boston. The coal pockets are of 2,000 and 8,000-tons capacity. The roof of the large pocket only is of wood. General plans for these were made by Adolph Suck, Boston; structural plans by Aberthaw Construction Co.

The only reason for the introduction of a comparatively new building material is the fact that it is either cheaper than existing modes of construction, or if not actually cheaper, is so far superior to existing methods in the results obtained as to justify its use. In the case of reinforced concrete it is only necessary to refer to the nearly universal application to prove economy. A few specific illustrations will emphasize the point.



ASSEMBLY BUILDING OF THE PIERCE AUTOMOBILE FACTORY. REINFORCED CONCRETE. Two 3-ton cranes run on all-concrete girders. The saw-tooth roof is shown from the lower side. Kahn system; constructed by the Trussed Concrete Steel Co., Detroit. Lockwood, Green & Co., architects.

Concrete of the usual mixture (1:3:6) has three times the working strength of the very best brick work and seven times the strength of ordinary, common brick work. Therefore, for columns, very much heavier loads can be carried on a given section, or smaller columns can be used, thus making a saving in floor space and in walls permitting larger windows to be used. With floors, longer spans are possible, giving a freer floor space. The beam between the wall columns can be set above the floor slab, thus allowing the windows to be set higher, and at the same time forming the wall below the sills of the next story. Reinforced-concrete floors are very much more rigid than those of wood or of steel. Being built monolithic in large sections with granolithic top, they are both germ and waterproof. There is no decay as with wood, but instead the cement becomes stronger with age. There have been long-time tests of cement showing a measurable increase for seventeen years.

These floors are also very poor conductors of heat, thus reducing condensation when there is heat and moisture on one side and cold on the other side of either floor or wall. Sounds cannot be heard through the floor so readily as through wood.

In textile mills, where there are long spans and light loads, the wood floor of standard mill construction is cheaper in first cost than concrete. Nevertheless, concrete is used on account of other advantages, which offset the slight difference in first cost. The agent of a large textile mill stated that looms running on the fourth and fifth stories of his mill, which was of the usual mill construction, caused such vibration that it was considered unsafe to run them at full speed. This reduced the output. When they were transferred to the lower stories the output was increased by 20 per cent and in addition there was a saving in the wear and tear on the machines, and in the power required to drive them. Vibration cannot occur with a rigid floor tied to the columns so that every support becomes a rigid brace. The Paris & Orleans Railway tested a steel beam and terra cotta floor by dropping a heavy weight on it and measuring the amount of vibratory movement and the length of time it lasted. A reinforced-concrete floor of the same span and weighing but little more than one-half as

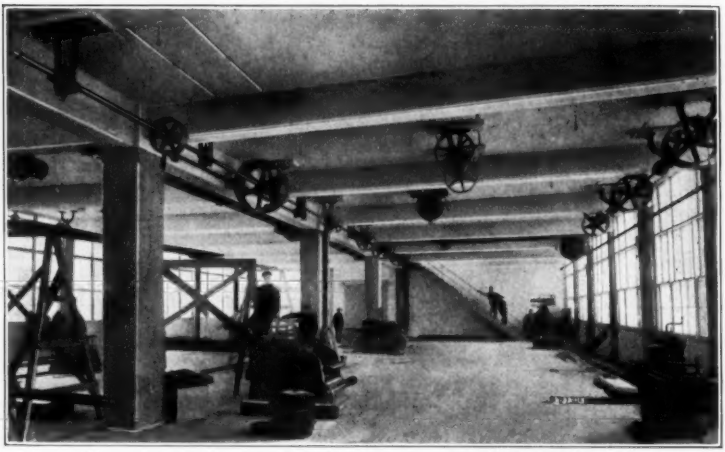
BAYONNE REFINERY OF THE PACIFIC COAST BORAX COMPANY.
The original building included one story of the portion in the foreground, with the four-story structure at the extreme right. The addition is the four-story portion surmounting the older one-story part in the front of the picture. Reinforced-concrete, built by the Ransome & Smith Co., N. Y.

CONCRETE-STEEL MANUFACTURING BUILDING ERECTED BY KEUFFEL & ESSER CO., IN HOBOKEN, N. J.

Louis Meystre & Son, architects. Built by Turner Construction Co., N. Y.

much had materially less movement and the vibration lasted a shorter time.

Wood floors in dye houses are subject to rapid decay from alternate wetting and drying and from the steam escaping from the tanks. On account of the waterproof quality of concrete floors and their proof against deterioration from moisture, a great saving can be made by their use. In some dye houses condensation of steam on external brick walls has caused their rapid distintegration. Concrete walls which are much less porous than brick and therefore have very much less absorption, have been found enduring and on account of their poor conductivity, condensation on the inside of solid walls, even, has been overcome. Because of the density and impermeability of con-



FIRST FLOOR, BODY BUILDING, AUTOMOBILE PLANT OF THE GEORGE N. PIERCE CO., BUFFALO.

The building is 60 ft. wide, with two 30-ft. bays. Attachment of shafting and motors to ceiling is well shown. Built on the Kahn system by the Trussed Concrete Steel Co., Detroit.

crete, tanks, vats, and filters can be built nearly as cheap as those made with the older building materials. It is possible to make the surface proof against the attack of dilute acids and of all alkalies or salts.

This construction is especially adapted to heavy loads—the heavier, the greater the advantage to be obtained in price over wood. The heaviest floor yet built sustains a live load of 5,000 pounds per square foot on a span of 14 feet. In machine shops and foundries where the loads are from 250 to 500 pounds per square foot there is some advantage in first cost, while the greater rigidity enables the machines to run without vibration, thus enabling better work to be done and adding to the life and reducing the repairs necessary to the machines themselves. The floor is not affected by mineral or vegetable oils which may be spilled upon it, and is non-absorbent so that it can be easily cleaned. Machines may be bolted through the slab of the floor without much difficulty. There are several convenient methods of attaching hangers for shafting to the ceiling. The best way is to embed bolts in the beams, projecting below a proper distance to receive wooden strips or steel channels to which hangers for shafting may be attached. This gives opportunity to attach the hangers at any point desired.

In jewelry factories, fine particles of gold dropped on the floor can easily be lost between the cracks of wood, but are readily recovered from a hard, smooth granolithic surface which has no joints.

The sanitary quality of these floors makes them of unusual advantage in factories where food products, such as meat, fish, and fruit, are handled; a scrubbing brush and hose render the floor as clean as when new with no danger of leakage to spoil goods in the stories below. For this reason hospitals for contagious diseases are also built of reinforced concrete. It has also been used for cold-storage warehouses because of its non-conducting qualities, and because also it is so easy to make the walls and floors hollow, still further reducing the conductivity. The tuning rooms in piano factories have been built with the hollow construction on account of its sound-proofness.

Where unusually heavy loads must be carried, say 1,000 to 1,500 pounds per square foot, as in coal pockets where coal teams drive underneath to load, concrete is considerably cheaper in first cost than wood.

In the power development of any plant there are many valuable applications. A large chimney can be made much cheaper of concrete than of brick, because it can be tied together to resist unequal stresses due to temperature, thus permitting lighter sections to be used. As it will withstand for an indefinite period a temperature of 500 degrees F., fire-brick linings can be omitted. The chimney is tied to its foundations and thus has greater stability than one of brick. In

UNDER SIDE OF FLOORS, ANDROSCOGGIN PULP COMPANY'S FACTORY, SOUTH WINDHAM, ME.

All reinforced concrete, by the Aberthaw Construction Co., Boston, from plans by I. W. Jones, Milton, N. H.

spark arresters where there is an elevated chamber, in which the sparks are extinguished by a water spray, the chimney can be suspended from the roof of this chamber without much difficulty. In the engine room the dead weight of concrete, which is greater than that of brick, makes it an excellent material for foundations for heavy horizontal engines, while at the same time it is much cheaper than brick; and being proof against attack of oil, it cannot disintegrate. In water-power development, the reinforced gravity dam has greater stability than the solid one. It is more stable with a freshet than when the pond is three-quarters full. Yet it has very much less material in it than the solid dam, it is quicker and cheaper of construction, and it can be made perfectly tight. In some cases the space under the dam has been used for the power-house, thereby saving room and cost of a building. Holes are cored through the buttresses supporting the up-stream face of the dam and a perfectly dry passageway may be built across the stream.* Penstocks can be made watertight and will last indefinitely without deterioration. Numerous experiments have been conducted on the danger of corrosion of steel embedded in concrete, and it has been conclusively proved that even if the concrete admit water the steel does not corrode if there is no current, and that rusty bars thoroughly coated with cement will after a month's time become bright and remain so.

High retaining walls have been built with a thin vertical wall tied to a broad base by means of counterforts at a cost one half that of solid masonry, at the same time having greater stability.

Our forests are being rapidly cut off, and the timber which remains is of inferior quality to that cut several years ago; there is difficulty in getting large sticks of yellow pine; all this renders floors of mill construction less secure and more expensive than they have been, making less difference in cost than there used to be between wood and concrete. On all-fireproof buildings, lower rates of insurance can be obtained. On a building of Merritt & Co., Philadelphia, where light iron work is manufactured, the rates on building and contents, which had been 3.57 per cent on their old building of mill construction, were reduced in the new fireproof structure to 1.82 per cent, a saving of 1.75 per cent per annum. This, considered as the interest on a permanent investment, would warrant an expenditure of a much larger sum than the actual difference in cost between mill construction of wood and brick and fireproof of all reinforced concrete. Moreover, the immunity from fire, avoiding loss of business and interruption of

* This phase of the use of reinforced concrete is discussed further and is also illustrated in Mr. von Schon's article elsewhere in this issue (p. 353).

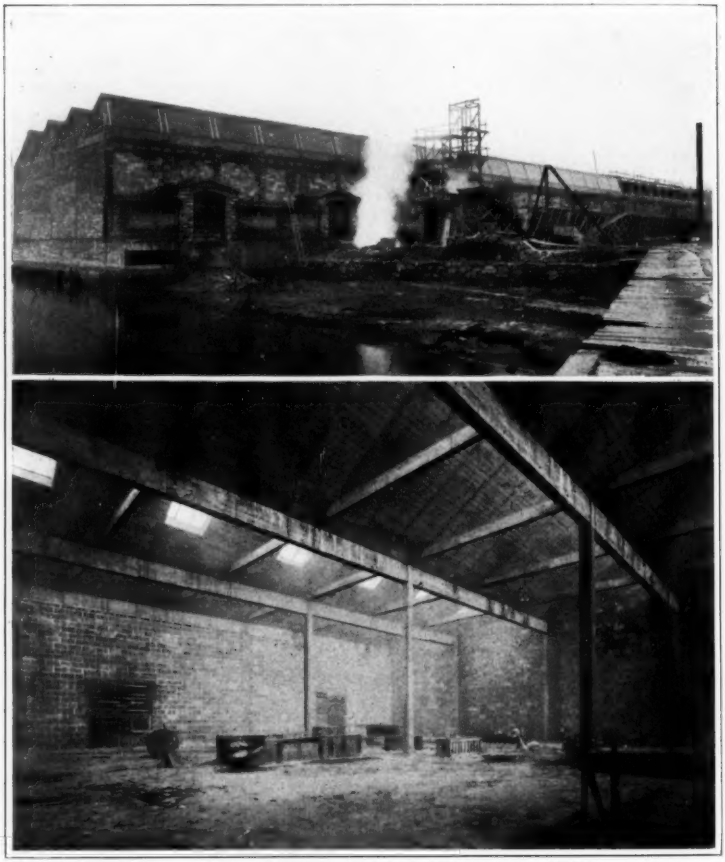
STORE HOUSE FOR THE WESTERN ELECTRIC CO., N. Y.

Eidlitz & McKenzie, architects. Reinforced-concrete construction by the Turner Construction Co., N. Y.

output, is of considerable value. In a few isolated and exceptional cases fireproof construction has been obtained for the same price as mill construction, but usually it will cost from 10 to 25 per cent more. A steel frame fireproofed will cost from 25 to 40 per cent more than reinforced concrete.

An advantage with this type of construction is that concrete is mixed and placed by common labor, which is the cheapest form of labor obtainable, with only a few experienced men to direct. This materially reduces the troubles with labor unions. Carpenters are plentiful and their unions are not so troublesome as those of the masons. Sand and stone are plentiful, and are to be found everywhere. Lumber suitable for forms is easily obtainable. The only materials coming from a distance are the cement and the reinforcing bars. Thus the greater part of the cost of a mill is returned to the community in which the work is done.

Concrete will carry its full load in one month. It is impossible to build so fast as to overload columns and walls. Greater speed has



EXTERIOR AND INTERIOR OF FACTORY FOR STOLLWERCK BROS., STAMFORD, CONN. Ernest Flagg, architect; W. L. Stoddart, consulting architect. Reinforced structure designed and built by Tucker & Vinton, N. Y. Monolithic bearing walls and concrete-block facing; hollow roof and walls to preserve uniform temperature. Saw-tooth roof, 50-ft. spans and 25-ft. bays.

been obtained than in any other type of construction. Examples of this are abundant. With necessary but not very expensive precautions, work can be done in mid-winter with safe ultimate results, and thus valuable time can often be saved. When a building is first completed it is weaker than it will ever be thereafter. During the process of construction, building materials are piled on the floors, often in excess of their figured loads, so that the owner can always feel assured that the building when accepted is absolutely safe. Concrete

exposed to view on all sides is its own inspector; there is no half way condition—it is either good or bad. The bad cannot be hidden until after acceptance. Specialists know this and it is a better guarantee of good work than a surety bond. If by any mischance any member is loaded to the point of failure, fine cracks appear first giving due warning, the failure coming gradually. Thus serious results can easily be avoided.

Serious accidents have occurred in the past, it is true, and have been reported in the daily and technical press. The causes have been apparent and do not cast reproach on concrete as a material of construction any more than a failure of brick, wood, or steel does today.

A number of years ago an engineer made complete plans for some grain elevators. These were circular tanks. The owner let the contracts and supervised the work. In his opinion there was an excess of steel. He left out some, with the result that when the bins were filled, they burst, allowing the grain to escape.

A small highway bridge was built in Indiana, of beam construction, designed by an engineer unfamiliar with reinforced concrete and erected by a contractor without experience. When put in service, it failed under the load of a road roller. It developed that the reinforcing bars were less than one-half the necessary size and were only long enough to reach just to the edge of the supports.

In the accident at Hotel Bixby, Long Beach, Cal., which occurred November 9, 1906, it was found that the columns were insufficient in size, the steel rods in beams and girders were not long enough to reach to a proper distance over the supports, and there was lack of proper supervision in the mixing and placing of materials.

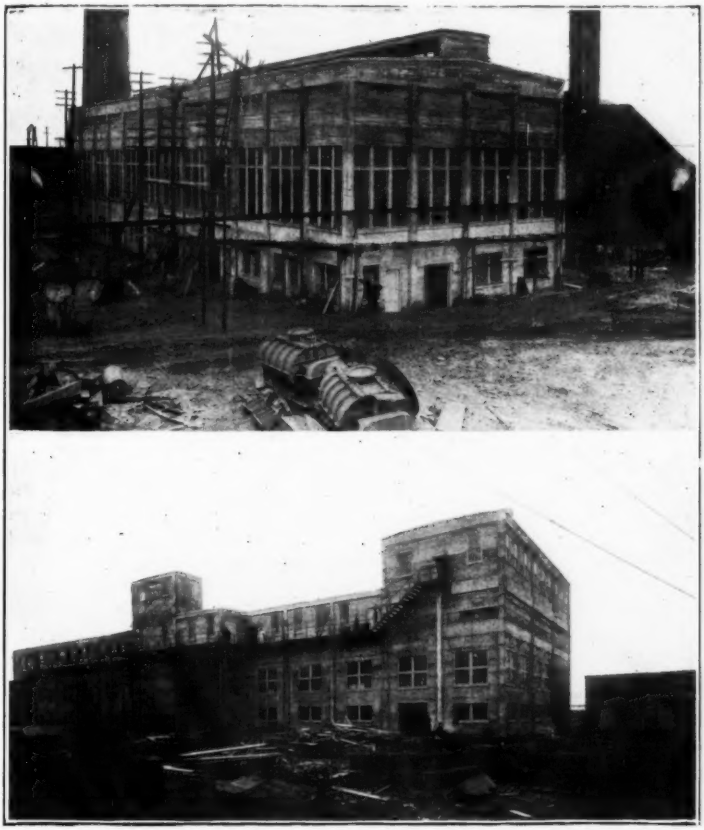
At Lawrence, Mass., the roof of a filter recently fell in. The work was put in in the autumn and froze before the cement set, alternately thawing and freezing during the winter until the centers were drawn in the spring. In this case, the concrete was injured by the weather.

These experiences should be interpreted to mean that only responsible contractors who have had experience should be permitted to figure on work, and that they should be supervised by competent inspectors. If owners would only realize it there is no greater extravagance in building work they can run into than to employ an engineer who cuts his commission, because this implies he is inexperienced, or to employ a responsible engineer for making plans only, thereby saving two or three per cent. on the cost of the job. They are likely to lose several times this in the quality of the work, with the danger of accidents which necessitate repairs or incur other expense in maintenance or operation far in excess of the saving on engineering.

There was a recent case of fire in the upper stories of an eight-story building used by a printing house. Water was thrown into the upper stories; as it could not run through the floors, it ran down the stairs. The employees in the lower stories, rather than go down the wet stairs, having perfect confidence in the safety of the building, remained in the lower stories looking out of the windows at the work of the firemen. Could this occur with any other type of construction?

As previously stated, designs can be accurately made and the results guaranteed. Nevertheless, this type of construction, more than any other, should be handled by specialists, as there are a number of details which they can care for which, if overlooked, would result in a building that might prove unsatisfactory to the owner. A few years ago a great deal was heard about systems of construction, every designer having a separate method and nearly every builder a different type of reinforcement. It has now been well established that any type of reinforcement whatsoever can be used to obtain certain results. The differences in cost between the different types of reinforcement and different methods of design are of minor consideration.

Only a few general hints will here be given regarding design. Tests on long-span beams identical in every way except that some were plain, others reinforced, proved that those which were reinforced developed twelve times the strength of the plain concrete. The principle of all designs is to use concrete in compression, and reinforcement wherever there is any chance for tension. In footings it is cheapest to use reinforcement, thus reducing the depth and saving in excavation, often avoiding trouble with water, thus making a saving in expense. Use an octagonal footing with bars running in four directions. In columns, the cheapest form of reinforcement to resist compression is cement. Mixtures as rich as one part cement to one part stone are safe for a load of 1,200 pounds per square inch. Use steel only to resist possible bending due to eccentric loads and to tie the joints between columns and floors rigidly together to resist wind pressure. In floors it is much better to use girder and beam reinforcement which is fabricated into units and tied in some way at the columns than to use a number of loose bars. A flat floor with bars running in all directions between columns can be made as strong as beam construction, and on account of the ease of building wooden forms, is often cheaper and quicker to construct than beam floors. Where desired, wooden floors can easily be laid on top of concrete and are more rigid than when laid over wooden beams. It is cheaper to construct curtain walls after the columns and floors are built, supporting these walls on top of the floor.



POWER HOUSE AND ELECTROLYTIC BUILDING FOR THE ORFORD COPPER COMPANY. The electrolytic building is 75 by 240 by 40 feet, and contains also laboratories and offices. Designed and constructed by the Curtin-Ruggles Co., N. Y.

There are several ways of treating exposed surfaces. The surface obtained direct from the wooden forms can never be considered a satisfactory finish for exposed exteriors. The cheapest and most durable way is to cut with sharp pointed tools 1/16 to 1/8 inch off the surface. This obliterates all marks of the wood, exposes the stone, and gives an even light gray color. A smooth surface can be obtained also by a wash coat of cement; this, however, is liable to be discolored by efflorescence or other cause and to lack uniformity. It is possible to obtain as handsome and ornamental surfaces as can be got from natural stone or terra cotta. These treatments, however, are too expensive to be considered in mill construction.

THE PURSUIT OF INVENTING AS A BUSINESS.

By George F. Stratton.

The interesting development which forms the topic of Mr. Stratton's commentary is perhaps peculiarly characteristic of the "American system" of mechanical production. At least, it belongs to the new order which has replaced the old shop full of "all-round mechanics" with the shop manned by tool tenders and officered by specialists. It may be new to some readers to know how definitely certain large concerns are setting out to answer the problem of providing, for the future, a supply of originating genius similar to that which formerly was associated with the skilful handling of tools at the bench.—THE EDITORS.

WHENEVER the first of the human race made his first attempt to subjugate existing conditions to his will and, prompted by the opening dawn of a reasoning faculty, made the simplest combination which did not before exist, then was the first era of invention. The first robe of skins was an invention and it must have been preceded by the invention of the implement, or method, by which that skin was secured.

Invention, then, is the oldest of the Arts, the Sciences and Trades. We are told that Tubal Cain was "an instructor of every artificer in brass and iron." The invention of the processes of smelting and working those metals must have long antedated him. Yet it is only within the last quarter of a century that inventing has been practiced as a regular business. For many centuries there have been men who have devoted their lives to philosophical research and scientific discovery; but they were rarely inventors. They were rather investigators and discoverers, probing deeply into the causes of natural phenomena and, by patient and laborious study, reducing their investigations to mathematical formulæ.

During the past century, with the advent of the steam engine and the consequent wonderful development of manufacturing, great inventors have appeared. But they usually developed into great manufacturers. Watt, the inventor of the condensing engine, after ten years of exhaustive experimenting devoted himself to the commercial exploitation of his engines. Stephenson, famed for his locomotive, established shops for its manufacture as soon as he had demonstrated its practicability. McCormick, the inventor of the reaper, became a great manufacturer. Ericsson, although a persistent and prolific inventor, was also always interested in manufacturing.

In contrast to all this, the modern tendency seems to be to keep the inventor inventing by affording him fair rewards for his genius, and to place the exploitation of his inventions in the hands of trained and skillful business managers. It may be safely stated that Thomas A. Edison is the inventor of the business of inventing. He has never been anything else but a professional inventor in the most exact sense of the term. He has never been a manufacturer. Although for a short period he was in partnership with a manufacturer, his attention was never given to the commercial end of the business. He devoted himself entirely to the improvement and development of the articles which the firm was making. He invented, always, and did nothing else. The first large sum of money which came into his possession ($40,000 for the stock ticker) he immediately devoted to the equipment of a shop for experimental purposes. He installed chemical appliances and materials, and an outfit of machines and tools which would meet every requirement for putting his ideas into concrete form. In the fitting up of that shop—in the purchase of machines and tools, and the intricate and delicate experimental apparatus—not one thought was given to the adaptability of it all to the commercial manufacture of any one article. Nor has it ever been so used. As new inventions were made and their practicability demonstrated by actual working apparatus made in that shop, they have been invariably turned over to some outside or subsidiary company for commercial exploitation. Edison concerns himself no further with them, except to watch for the possibility of improvement in them. The brain which today perfects a phonograph, turns tomorrow to a storage battery. He has patented eight-hundred inventions. His average for some years has been two each month.

And yet, this inventor, who has confessed to almost total ignorance of the practices of commercial life, shows surprising ability for systematic and business-like conduct of his profession. He wastes no time upon ingenious toys. "If it can be done, is it worth anything?" is his invariable question upon first confronting a problem. If he is convinced that his ideas will conduce to the advancement of industry, or science, or art, he goes ahead—and never gives up until he has convinced himself of the practicability or impracticability of that idea. He says:—"I can't recall a single problem in my life, of any sort, that I ever started on, which I didn't solve or prove that it couldn't be solved."

The most striking instance, not only of his persistence but also of his systematic methods, is seen in the accounts of the invention of the

incandescent lamp. The filament gave him the greatest trouble and, in his search for suitable material, he sent hundreds of letters to United States consuls in all parts of the world, requesting samples of bamboos, reeds, and other vegetable fibres, and he followed this up by despatching special explorers to search wild and uncivilized countries where, as Frank McGowan (one of the explorers) said, "A United States consul was usually eaten before he'd had time to open much mail." Between three thousand and four thousand samples were collected from this systematic search, and of all these only two or three were found to be of any use. But they were sufficient, and resulted in the incandescent lamp. Again, in the search for the best material for phonographic records, he sent seven men into India, China, Africa and other parts of the world for new vegetable bases for waxes. It took five years to find the right article, but then it was the right one and is in use today. Another remarkable instance of his systematic method is shown in his determination of the presence of radium in almost all substances. Upon each of seven hundred sensitive photograph plates he caused to be placed fifty different substances. The plates were then locked up in a dark room for seven weeks, and the presence of radioactivity in each of these thirty-five thousand substances was detected when the plates were developed.

All that is systematic business, and a method of doing business which would be creditable to the most determined and enterprising Captain of Industry at the head of any manufacturing plant in the world.

Leaving the Wizard of Menlo Park, we come to a large group of professional inventors who have appeared in the last quarter of a century. These comprise the experimental forces of the great industrial works. They are men engaged under salary to invent and develop improvements in the articles manufactured—to meet the demands for new articles and to devise new methods of manufacturing. They are men who come from a variety of businesses and professions. Frequently they are trained engineers or chemists. Quite as frequently they are mechanics of no knowledge of mathematics or first principles, but with wonderful mechanical ingenuity.

In the General Electric Company's works at Schenectady, N. Y. and Lynn, Mass., there are to be found, among the expert force, an ex-newspaper man, a groceryman, a fisherman, a cabinet-maker, and a one-time hack-driver. This company employs, in its various component plants, a total of thirty thousand hands and spends upwards of two and a half million dollars, annually, in making and developing

inventions. It employs, in addition to the experts, a corps of twelve patent attorneys and twenty-eight assistants. The great Westinghouse Electric Company maintain almost as large and expensive a department. The Bell Telephone Company, the Hoe Printing-Press Company, the National Cash Register Company, the United Shoe Machinery Company, and scores of smaller companies, carry a force of men upon salary whose duties are to invent and to develop the best possibilities of inventions.

Then, we find another group of professional inventors—smaller in numbers and engaged upon humbler matters than the experts above mentioned. In fact, they are scarcely ever known as inventors, their ideas being seldom patented. In almost every large plant where a quantity of machinery is used, may be found one of these men. In one shop he will be known as a "tool expert." In another as an "adjuster." In yet another he will be called the "doctor." He is frequently taken from the ranks of the working mechanics. He will be seen wandering around the shops and studying the machines—no matter how large or small. The great boring mill and the smallest bench tool alike engage his attention. He secures his job, and holds it, by his unusual ingenuity in devising little things—a bolt here, to guard against some special strain; a new pulley there, to increase the speed of a certain part. He devises small attachments to enable a machine to do some special job. He sees a method of saving oil on one machine, and of facilitating the feeding of material to another. He keeps an eye on the hang of the shafting and the balance of pulleys; and he designs methods of adapting the motor-drive to belt-driven machines. If a contract for new work is undertaken he is consulted as to what machines and tools can be used, and how they may be adapted to handle the work with the greatest economy and expedition. He makes suggestions upon the drawings and patterns of new work, which frequently result in such modification as will greatly cheapen the production, without affecting the efficiency or quality. He is inventing, always; little matters, it is true, but they are recognized as being of such importance and utility that a salary of from $50 to $100 per week is by no means uncommon.

From this group of inventors have come some of the greatest of labor-saving devices. The metal and textile industries of the world especially owe much to these unassuming and comparatively unknown men. It has been stated that a great machine shop in New England has easily effected a saving of $50,000 annually by the services of one of these "doctors."

Of course, outside of these independent and salaried professional inventors is the great army of men who, while actively engaged in occupations embracing every line of human endeavor, develop new ideas, often of great value and just as often altogether out of their line of regular work. An inquiry into the personalities of a few dozen inventors, to whom patents have been granted during the past year, shows some remarkable facts. Among them, a sea-captain has patented a steering gear for automobiles, while a carriage-builder has invented a ship's capstan. A blacksmith has papers for a fishing-reel, a shoemaker, for a typewriter; a physician, for a door lock, and an undertaker, for a hoisting derrick; and many others show just as strange deviation from their regular walks of life.

These inventors are, however, sporadic. They cannot be said to be in the business of invention. Moreover, a very large proportion of such men are utterly impracticable in their ideas, although they undoubtedly show great ingenuity. Good, all-round inventors—men who make inventing their life work—are very rare, while the demand for them is increasing in a surprising degree. This demand is due, of course, to the consolidation of manufacturing industries into great central organizations with vast resources, and ever-growing eagerness for new and improved methods of manufacturing.

Aside from the salaried positions which are being offered in increasing numbers by the great corporations, is the broad opportunity for independent inventors. Given a man of bright mechanical ingenuity and, with a workshop suitably equipped with tools, his services would be greatly in demand by the smaller manufacturers, to solve mechanical problems for them. If such a man would leave the exploitation of his inventions to others, and keep ever before him the invariable maxim of Mr. Edison: "If it can be done, is it worth anything?" thus withstanding the disastrous temptations of every inventor to jump at every mechanical puzzle, for the sole reason of solving that puzzle, his services would be continually in demand, and his success assured.

EFFICIENCY IN THE BURNING OF FUEL UNDER THE STEAM BOILER.

By William D. Ennis.

I. THE INFLUENCE OF AIR SUPPLY UPON ECONOMY OF COMBUSTION.

One of the very significant things in the field of mechanical engineering just now is the wide-spread and eager movement in search of better economy in the boiler room. As Mr. Bolton put it in his series on superheated steam which was concluded in our May issue: "If steam is to retain its place as a method of power development, its whole cycle of operations must come under the definite and concentrated treatment which has been accorded in the past mainly to one end of the operation, viz., the steam-cylinder part of the combination."

Mr. Ennis's discussion which begins in this issue is therefore as timely as it is thorough. He starts on the solid ground of fact and physical law, and makes perfectly clear what conditions are necessary to the economical burning of coal under the boiler, and what steps should be taken to discover whether these conditions are secured in any given plant, or if not, what remedies should be applied. His articles, which will be continued, will prove of great value to the careful and progressive power-plant manager or owner. The next section will deal with the measurement and control of draft.—THE EDITORS.

THERE is a notable tendency in present-day steam plant practice, toward better operation of boiler furnaces. It has long been known that the average steam boiler generally operates at an efficiency seriously lower than that which may easily be reached by proper firing. To a certain extent, this has been due to the fuel. American steam-boiler practice began in the eastern United States with anthracite coal as fuel. With the gradual extension of manufacturing to the West, the available steam coal has been one containing lower percentages of carbon and higher percentages of hydrocarbon. Boiler settings and furnaces designed for anthracite, which is nearly all carbon, were found unsuitable for the highly volatile bituminous coals. In fact, tables have been published showing the relation of possible boiler efficiency to quality of coal—as if there were some physical law prohibiting the attainment of even a proportionately equal useful quantity of heat from the poorer grades of coal.

There is no such physical law. The reasons why boiler efficiencies have been, and are still, less with the Western soft coals than with Eastern anthracite, is that grates, furnaces, and settings designed for the latter fuel are entirely inapplicable to the combustion of any fuel high in volatile hydrocarbons. For some years, this fact has been pretty well established; but from inertia or some other cause, a large

proportion of soft-coal burning plants continue to operate at efficiencies from one-half to three-fourths as high as they might readily obtain by proper furnace construction.

A similar low efficiency, as compared with that of good operation, is found in many plants burning hard coal. A steam boiler, as a machine, differs markedly from a steam engine. In the case of the latter, if it be once started under proper conditions of load, pressure and vacuum, the operator can do practically nothing that will affect the economy. With the boiler, every move that is made has a vital relation to the fuel efficiency. Economical engine performance is a matter of design. Economical boiler performance, while limited by design, is, within those limits, a matter of operation.

Since large boiler plants are comparatively recent, and the operation of the steam boiler has heretofore been committed to the least intelligent class of labor about the power plant, it is not surprising that the results of this operation have fallen far from the ideal, whether anthracite or soft coal has been the fuel.

At the present moment, several causes are contributing toward a correction of this condition. We have enormous power plants, in which even a small percentage of loss may represent a cost equalling the income of a millionaire. The stake here is so large that boiler operation must be given attention. The advent of the gas engine, also, has forced the steam engineer to seek the largest possible immediate gain at the fire-door and damper. Recent devices for the accurate indication and recording of flue-gas and furnace temperatures, and of intensity of draft, have facilitated investigation of these subjects in their relation to economy; and new forms of recording apparatus showing the chemical composition of flue gases have permitted close and continuous observation on this most essential subject.

The revival of interest in boiler economy has been most pronounced during about a year's time. It bears all the ear-marks of a revival not yet on the wane. It would seem probable that it marks the beginning of a general increase in boiler efficiency from 50 or 60 per cent to an average of 70 to 75 per cent. Concurrently, a marked influence is beginning to be exerted on questions of engineering involved in boiler, setting, furnace, grate, and stoker design.

The chapter of the day in this most interesting evolution might well be headed, "Draft." As will be shown, the subject matter of this chapter is rather air supply than draft; the two not being identical. Not to quarrel, however, over a matter of terminology, the essence of the subject is that, in the past, coal has been burned almost universally with an excessive amount of draft. So serious has been

the loss from this excess, that it is not too much to suggest that the damper should now be regarded as the rudder wherewith the power plant must be guided—bearing the same relation to economy that the pressure gauge does to the existence, as an entity, of the power-generating equipment.

It is not necessary to break any existing records. What is necessary, is to equal existing records in actual, average daily operation. We now have recorded boiler tests showing efficiencies above 80 per cent. If we can advance from our present average of 50 or 60 per cent to this former figure, we shall have made a greater gain, and on an infinitely greater scale, than if we were to increase the 80 per cent to the 100 per cent of perfect operation. As a matter of fact, we cannot expect to increase greatly the efficiency figure of 80 per cent, even under the exceptionally favorable conditions conducive to record-breaking; much less to so improve the conditions of combustion as to surpass it under the harassments of average operation. Even if the loss to the stack were entirely overcome (which might be done theoretically, by using a series of economizers which would utilize all the heat in the gases down to the temperature of the atmosphere) we should still have to face losses due to radiation, loss of coal in ash, and power to produce draft. One of the most efficient plants in existence found that the two former losses alone amounted, on the average, to 10.4 per cent. If draft were produced naturally, and the air supply could be kept down exactly to that amount which is necessary for complete combustion, the loss to the stack with gases only 400 degrees above the temperature of the air would be $12.6 \times 400 \times .2375 = 1{,}200$ B. T. U. per pound of coal, or say 8.6 per cent. Practically, therefore, our efforts for improvement in power-plant operation may best be directed at the damper.

To simplify our investigations, we may assume that the fuel is pure carbon, developing, when completely consumed, 14,500 B. T. U. This quantity of heat is evolved when the reaction $C + O_2 = CO_2$ occurs, or when a sufficient quantity of oxygen is supplied to permit of the production of carbon-dioxide gas. If the supply of oxygen is limited, or if only a limited quantity of oxygen is so mingled with the carbon as to unite with it chemically, the carbon may unite with a lesser proportion of oxygen to form carbon monoxide; the reaction being $C + O = CO$. In the combustion of carbon under these conditions, the heat evolved per pound of carbon is 4,400 B. T. U. Consequently, a deficiency of oxygen may result in a combustion efficiency of only $4{,}400 \div 14{,}500 = 30.4$ per cent.

To consume one pound of carbon, completely, oxygen must be

supplied in proportion to the relative combining weights of the two elements. The value of oxygen to carbon in carbon dioxide is 32 ÷ 12, or as 2 2/3:1. Oxygen amounting to 2 2/3 pounds must therefore be supplied for each pound of coal burned. As air contains 23 per cent by weight of oxygen, the air supplied per pound of coal must be 11.6 pounds. With this amount of air thoroughly mixed with the carbon, all of the latter will be burned to CO_2, evolving its full calorific value of 14,500 B. T. U.

If the supply of air is cut down 1 per cent, a corresponding percentage of carbon will find no oxygen for combination. Under certain circumstances this 1 per cent of carbon might be discharged at the slack, representing at least a 1 per-cent loss in heating value of the fuel. It is more likely that this carbon will rob another 1 per cent of carbon of its share of the oxygen, so that 2 per cent of carbon will be burned with a quantity of oxygen only half sufficient for complete combustion. Carbon monoxide will therefore be formed, entailing a loss of 70 per cent, which applying to 2 per cent of the fuel entails a loss of 1.4 per cent of the total heating value. Roughly speaking, therefore, a 1 per cent shortage of air supply involves a 1½ per cent loss of fuel. There is also a further loss due to the decreased temperature in the furnace and consequent slower transmission of heat to the steam.

A far more serious loss occurs in case of an excess of air supply. All the air supplied to the fuel is discharged to the stack at a temperature much higher than that at which it reached the grate. This elevation of temperature measures the loss of heat due to the air supply. For every pound of air discharged at a temperature, say 400 degrees above that of the atmosphere, there are wasted 400 × .2375 = 95 B. T. U. We have seen that at the least 11.6 pounds of air must be supplied per pound of carbon, entailing a loss (including the carbon itself) of 12.6 × 95 = 1,200 B. T. U. For every 10 per cent of air supplied in excess of the necessary 11.6 pounds there is a further loss of 110 B. T. U., say 0.75 per cent of the heat in the fuel. In ordinary practice, the excess of air is rarely under 50 per cent—a loss of 3.75 per cent in heating value—and is often 200, 300, and even 500 per cent—making the loss in the last case 37½ per cent of the total heat value paid for in the coal.

An additional loss, not permitting of such precise estimation, is due to the decreased furnace temperature. If the quantity of air supplied is just sufficient for combustion, and the specific heat of the gases be taken at .2375, the temperature in the furnace is necessarily 14,500 ÷ (12.6 × .2375) = 4,850 degrees. If twice this quantity

of air be supplied, the furnace temperature will be 14,500 ÷ (24.2 × ,2375) = 2525. The rapidity of transmission of heat through tubes, from furnace to water and steam in the boiler, depend upon the difference in temperature inside and outside the tubes. If the temperature inside is 300 degrees, and the gases leave the boiler setting at 500 degrees, we have the following conditions:

	Case. I.	Case II.
Air supplied per lb. of fuel	11.6 lb.	23.2 lb.
Furnace temperature	4,850 degrees	2,525 degrees
Exit temperature	500 "	500 "
Average temperature of gases	2,675 "	1,513 "
Temperature inside tubes	300 "	300 "
Average difference in temperature	2,375 "	1,213 "

It is easy to see that a very much less quantity of heat will be transmitted to the steam, in a given time, in Case II than in Case I. Some writers would say that the difference in quantity of heat transmitted would be proportional to the difference in temperature, in which case only about half as much heat would be transmitted when the air was 100 per cent in excess. The actual difference in transmission is probably not so great. Further, in Case II, the velocity of gases would be greater and the time for transmission consequently less. This would make the loss in efficiency due to excess air still greater. Another modifying factor is that the "exit temperature," or temperature of gases as they leave the boiler would probably be lower in Case II. Practically, the total quantity of heat transmitted to the boiler is kept nearly uniform for widely varying rates of air supply by decreasing the gas velocity (or in other words, by checking the draft) concurrently with decrease in air supply.

This feature of excessive air supply is not usually considered in estimating the losses due thereto. The loss by reason of the greater amount of heat delivered to the stack would seem to be sufficiently serious to induce any power-plant owner to set about reducing the excess, without this further argument.

As has been noted, a deficiency of air supply results also in a lessened furnace temperature due to the formation of carbon monoxide instead of carbon dioxide. Under certain circumstances, which will be described later, there is often at one and the same time both an excess of air and a partial formation of carbon monoxide. In this case, the temperature of the furnace may actually increase with increasing percentages of CO, up to a certain point.

Much progress has been made in reducing air excess. At an early stage of steam-boiler practice it was thought that at least 100 per cent of excess air was necessary to secure complete combustion;

the idea being that the air and gases could not be thoroughly mixed without this excess. Even quite recently, a well-known writer recommended an air supply of 19 pounds per pound of coal as conducive to highest efficiency. This would give an excess of 64 per cent. We are fortunately beginning to get still more close to perfect operation, in well managed plants, one of which is regularly operated with an air excess of not more than 30 to 40 per cent. Under such circumstances, we may soon expect to hear of furnace temperatures much higher than 3,000 degrees, which was the highest recorded at a quite recent date.

The study of air supply and its effect on combustion is made possible by suitable apparatus for the analysis of flue gases. Confining our argument to the assumed case of pure carbon, these gases contain, mainly, oxygen, nitrogen, carbon monoxide and carbon dioxide. As has been seen, the best flue gas from the standpoint of economy would be one containing carbon dioxide and nitrogen only: all of the carbon being completely consumed, without the disadvantage imposed by an excess of air supply. With an excess of air, the gas would consist of carbon dioxide, nitrogen and oxygen; with a deficient air supply, carbon monoxide would be found, without any oxygen. In actual practice, on account of the incomplete mixture of air with the gases from the fuel, it is usual to find all four constituents together—some carbon monoxide, denoting incomplete combustion, actually accompanying free oxygen; this latter being the evidence of an excess of air supply over that actually necessary for complete combustion. It is evident, therefore, that the effective mixture of the air and gases in the furnace is of fully as much importance as the mere supplying of a sufficient quantity of air. In the case of fuels high in hydrocarbon it is perhaps of the greater importance.

Disregarding the question of mixing, we may proceed to investigate the relation of flue-gas composition to combustion efficiency in the case of pure carbon. By supplying 11.6 pounds of air per pound of fuel, we produce 12.6 pounds of gas, of which 3.67 pounds is carbon dioxide, the balance being nitrogen. The percentage of carbon dioxide by weight is therefore 29.1. Flue gases are usually analyzed by volumetric methods, the constituent parts being expressed in percentages of volume. The relative specific volumes of the several gases under consideration are as follows:

Carbon dioxide	.0909
Carbon monoxide	.143
Oxygen	.125
Nitrogen	.143

A gas containing 29.1 per cent of carbon dioxide and 70.9 per cent of nitrogen, by weight, would therefore contain, by volume, about 21 per cent of the former and 70 per cent of the latter. This 21 per cent is the highest possible proportion of carbon dioxide that can be contained in flue gases resulting from the combustion of carbon in air. If more air is supplied, no greater amount of carbon dioxide can be formed; and as the total amount of gas will be greater, the proportion of carbon dioxide will be less. If less air is supplied, at least a proportionately less amount of carbon dioxide will be produced, and as the fraction representing the percentage is equally decreased in both numerator and denominator, the value of the fraction is less. This is on the assumption that the carbon is burned in air. If an atmosphere of pure oxygen could be provided for combustion, the gas might be entirely carbon dioxide. There has recently been placed on the market a so-called fuel-saving device which is alleged to supply pure oxygen for combustion, air being excluded; but as the atmosphere of pure oxygen is to be provided by the mixture of 2½ pounds of powder (composition not stated) and 40 pounds of water, per ton of coal, some new and remarkable chemical reaction must be necessary to develop the 5,340 pounds of oxygen necessary to consume one ton of fuel.

When an excess of air is supplied, if the number of pounds of air per pound of fuel be x, the total gas produced will be $x + 1$, pounds. The oxygen used for combustion will be 2.67 pounds, the weight of carbon dioxide produced will be 3.67 pounds, the weight of excess oxygen will be $.23x - 2.67$, the weight of nitrogen $.77x$. From these values, we may calculate the percentage, by weight and by volume, of carbon dioxide, oxygen, and nitrogen in any flue gas, in relation to the amount of air supplied. The relation of these percentages by volume is shown by the chart, Figure 1, on page 421, the values being given in Table 1 on page 420.

Suppose, now, that there is a shortage of air supply. As has already been shown, for each 1 per cent of air shortage, 2 per cent of the carbon will be burned to carbon monoxide instead of carbon dioxide. Let x be the number of pounds of air supplied, this being less than 11.6 pounds, the quantity necessary for complete combustion. The shortage of air, in pounds, is $11.6 - x$; or in per cent, $(11.6 - x) \div 11.6$. The percentage of carbon burned to carbon monoxide will be twice this, or $(11.6 - x) \div 5.8$. Reducing percentages by weight to percentages by volume, as in Table I, we may add to the chart a curve representing percentages of carbon monoxide. The maximum proportion of this substance in the total product of

I.	II.	III.	IV.	V.	VI.	VII.	VIII.		IX.		X.		XI.	
Air supply, per cent. of theoretical.	Air supply, lb.	Weight of flue gases, lb.	CO_2, lb.	CO, lb.	O, lb.	N, lb.	CO_2, by vol. Total.	Per cent.	CO by vol. Total.	Per cent.	O by vol. Total.	Per cent.	N by vol. Total.	Per cent.
0	0	0	....	....	....	....	....	....	....	....	....	....	....	...
10	1.16	2.16	....	.47	....	.9	....	....	.067	35.0	....	....	.128	66.
20	2.32	3.32	....	.93	....	1.8	....	....	.133	34.0	....	....	.257	66.
30	3.48	4.48	....	1.40	....	2.7	....	....	.200	33.6	....	....	.385	65.
40	4.64	5.64	....	1.86	....	3.6	....	....	.266	34.1	....	....	.514	66.
50	5.80	6.80	....	2.33	....	4.5	....	....	.333	34.2	....	....	.642	66.
60	6.96	7.96	.73	1.86	....	5.4	.066	5.9	.266	24.0	....	....	.771	69.
70	8.12	9.12	1.47	1.40	....	6.2	.134	11.0	.200	16.4	....	....	.886	73.
80	9.28	10.28	2.20	.93	....	7.1	.200	14.8	.133	9.9	....	....	1.02	75.
90	10.44	11.44	2.94	.47	....	8.0	.267	18.0	.067	4.5	....	....	1.14	77.
100	11.60	12.6	3.67	....	....	8.9	.333	20.7	....	....	....	....	1.27	79.
110	12.8	13.8	3.67	....	.3	9.9	.333	18.7	....	....	.0375	2.1	1.41	79.
120	13.9	14.9	3.67	....	.5	10.7	.333	17.4	....	....	.0625	3.2	1.53	79.
140	16.2	17.2	3.67	....	1.1	12.5	.333	14.8	....	....	.1375	6.1	1.78	79.
160	18.6	19.6	3.67	....	1.6	14.3	.333	12.9	....	....	.200	7.8	2.05	79.
200	23.2	24.2	3.67	....	2.7	17.9	.333	10.3	....	....	.338	10.5	2.55	79.
250	29.0	30.0	3.67	....	4.	22.3	.333	8.3	....	....	.500	12.4	3.19	79.
300	34.9	35.9	3.67	....	5.3	26.9	.333	6.9	....	....	.663	13.7	3.84	79.
400	46.4	47.4	3.67	....	8.0	35.7	.333	5.2	....	....	1.00	15.5	5.10	79.
500	58.0	59.0	3.67	....	10.6	44.6	.333	4.1	....	....	1.33	16.5	6.37	79.
600	69.6	70.6	3.67	....	13.3	53.6	.333	3.4	....	....	1.66	17.2	7.66	79.

Col. II = Col. I × 11.6 ÷ 100.
Col. III = Col. II + 1.
Col. VI, for Col. I = 100 or over = .23 × Col. II − 2.67.
Col. VII = .77 × Col. II.

NOTE: For percentages of air supply below 50, volumes of CO and N are given in percentages of volume of clean gases, not including free C. Computations by 10-inch slide rule.

TABLE I. FLUE-GAS ANALYSIS—PERFECT MIXTURE.

combustion is found when 5.8 pounds of air are supplied per pound of fuel, giving 6.8 pounds total gas, 2.33 pounds carbon monoxide, or 34.3 per cent by weight. If the air supply be less, proportionately less monoxide is formed: if greater, carbon dioxide is produced.

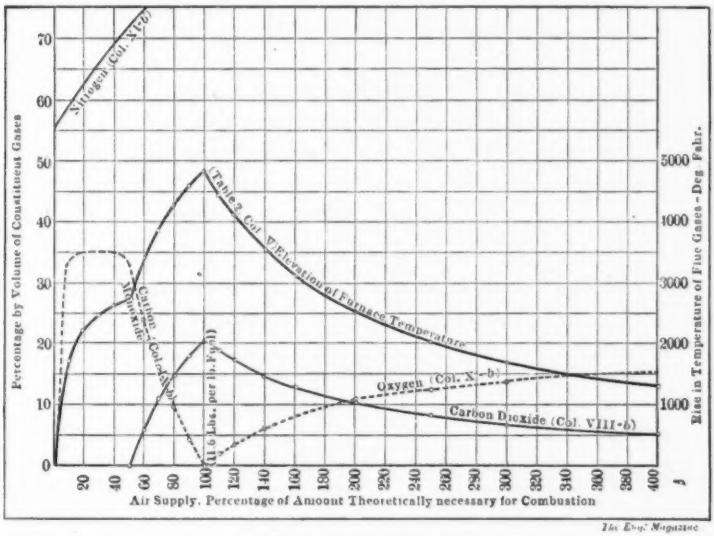

Nitrogen (Col. X-b)
(Tables Col. V)
Elevation of Furnace Temperature
Carbon Monoxide (Col. IX-b)
(Tables Col. VI)
Oxygen (Col. X-b)
Carbon Dioxide (Col. VIII-b)
Percentage by Volume of Constituent Gases
Rise in Temperature of Flue Gases - Deg Fahr.
Air Supply. Percentage of Amount Theoretically necessary for Combustion
The Engr. Magazine

CHART V. FLUE GAS COMPOSITION FOR CARBON BURNED IN AIR WITH PERFECT MIXTURE OF GASES.

It is evident, from a survey of this chart, that certain fixed relations exist between the proportions of the various constituent gases. The percentages of CO, CO_2 and N begin at zero for zero air supply; the first increases to a maximum at 50 per cent and then decreases to zero at 100 per cent, at which point CO_2 is at maximum and free O begins to appear. After passing beyond 100 per cent CO_2 decreases while O increases, *ad infinitum*, and N remains practically constant at 79 per cent under all usual conditions. These relations are, however, strongly modified by the incomplete mixture of the gases.

One relation that is of especial value in checking the results of actual analysis is that between excess oxygen and carbon dioxide. We have seen that where air was supplied in excess, the total weight of gas being $x + 1$ pounds, the oxygen amounted to $.23x - 2.67$ pounds and the CO_2 to 3.67 pounds. The sum of the two is therefore $.23x + 1$ pounds, which for high values of x bears a practically constant ratio to the total weight of gas. If we take the percentages by volume instead of by weight, we have the following:

Gas.	Weight in lb.	Relative volume.	Actual volume.	Percentage volume.
Oxygen	.23x — 2.67	.125	.0287x — .333	sum =
Carbon dioxide	3.67	.0909	.333	20.7 per cent.
Nitrogen	.77x	.143	.11x	
Total.....	x + 1.00		.1387x	

This shows that the combined volumes of oxygen and carbon dioxide in the gas are always 20.7 per cent of the total.

Under the conditions assumed, if we know the percentage of either oxygen, nitrogen, carbon dioxide or carbon monoxide, we have the data necessary to show whether combustion is perfect; at which point, the chart shows there should be present no oxygen, no monoxide, 20.7 per cent of dioxide and 79.3 per cent of nitrogen. Under actual conditions, perfect combustion is never obtained. To determine how nearly such perfect combustion is attained is the work of the gas analyst. No method for the direct determination of nitrogen is known. The percentage of oxygen would seem to tell the whole story; but at high combustion efficiency this percentage becomes very low. The percentage of monoxide or dioxide alone would tell nothing, because for each possible percentage of each of these there are two possible percentages of air supply. Ordinarily, the dioxide and the monoxide (or oxygen) must both be determined. If dioxide is 15 per cent, and monoxide is present, we know that the air supply is deficient and that the lower of the two possible air percentages (80 and 140) is indicated: but if the monoxide is absent, or oxygen is found, then the higher of the two percentages of air is present. In a large majority of the cases, the air supply is excessive. Having once ascertained this to be the case, the analysis of the gases for carbon dioxide answers every purpose in indicating the efficiency of combustion.

There is another reason why the determination of carbon dioxide is regarded as the crux of the situation. The phenomenon of incomplete mixing results in the simultaneous production, in a single furnace, of oxygen and carbon monoxide. These concurrent products make it impossible to calculate with any degree of exactness just what the economy may be from determination of either of these constituents: but regardless of stratification and short-circuiting of gases, if a fair sample of the average is secured, the percentage of dioxide is a certain index of economy. We know that every increase in this percentage must necessarily conduce to higher efficiency. There can be no doubt that of two furnaces, the one producing the higher proportion of CO_2 in the flue gases is the more economical.

Besides the relative proportions of the gases, Chart I shows the theoretical elevation of temperature due to various percentages of air

utilized in combustion. If we assume the specific heat of the gases at .2375, then if x = the number of pounds of air supplied per pound of fuel, x + 1 = weight of products of combustion, and the heat absorbed by these products per degree of temperature elevation is .2375 (x + 1), and if H = total heat of combustion, as burned, of one pound of the fuel, the elevation in temperature is H ÷ .2375 (x + 1). For 11.6 pounds of air or more per pound of fuel, this becomes 14,500 ÷ .2375 (x + 1), for perfect mixture. The computation of temperatures for various air supplies is given in Table 2, the results being shown on Chart 1.

I. Air supply, per cent. of theoretical.	II. Total wt. of flue gases, lb.	III. B. T. U. absorbed by gas per 1 degree rise in temperature.	IV. Heat generated by combustion of 1 lb. carbon.	V. Rise in temperature of gases, deg. F.
0	0	0	0	0
10	2.16	.512	880	1,720
20	3.32	.79	1,760	2,230
30	4.48	1.06	2,640	2,490
40	5.64	1.34	3,520	2,630
50	6.80	1.62	4,400	2,710
60	7.96	1.89	6,420	3,410
70	9.12	2.17	8,440	3,890
80	10.28	2.44	10,460	4,290
90	11.44	2.72	12,480	4,590
100	12.6	3.00	14,500	4,830
110	13.8	3.28	14,500	4,420
120	14.9	3.53	14,500	4,120
140	17.2	4.09	14,500	3,550
160	19.6	4.66	14,500	3,120
200	24.2	5.74	14,500	2,525
250	30.0	7.12	14,500	2,040
300	35.9	8.55	14,500	1,700
400	47.4	11.25	14,500	1,290

Col. III = Col. II × .2375.
Col. IV = (Coal burned to CO × 4,400) + (Coal burned to CO_2 × 14,500).
Col. V = Col. IV ÷ Col. III.
Computed with 10-inch slide rule.

TABLE 2. FURNACE TEMPERATURES, PERFECT MIXTURE.

CONTROLLABLE LOSSES OF HEAT AS INDICATED BY FLUE GAS ANALYSIS.

Since a definite relation exists between the percentage of carbon dioxide in flue gas and the amount of air supplied for combustion, it is easy to calculate the losses corresponding to various stated proportions of the former. We have seen that the heat lost per pound of gas is .2375 ($t^1 - t^0$), if t^1 be the temperature of flue gases and t^0 the temperature of air supply. For 11.6 pounds per pound of carbon, the air supply theoretically necessary, the loss in B. T. U. per pound of fuel is 12.6 × .2375 ($t^1 - t^0$) = 3.00 ($t^1 - t^0$). For any other quantity of air supplied, say x pounds, the loss in B. T. U. (x + 1) .2375 ($t^1 - t^0$). Dividing this by 145, we have the loss in percentage

of the total heat in the fuel. These calculations are given in detail in Table 3, the corresponding relations being shown on Chart 2.

Air supply, per cent. of theoretical.	I. Weight of products of combustion, lb.	II. Percentage of CO_2 by volume.	III. Percentage loss to stack for (t'-t°) as below. 400°	IV. 500°	V. 600°	VI. Percentage loss due to incomplete combustion.
0	0	...	...	...	...	100
10	2.16	...	1.4	1.8	2.1	94
20	3.32	...	2.2	2.7	3.2	88
30	4.48	...	2.9	3.7	4.4	82
40	5.64	...	3.7	4.6	5.5	76
50	6.80	...	4.5	5.6	6.8	70
60	7.96	5.9	5.2	6.5	7.8	56
70	9.12	11.0	5.9	7.4	8.9	42
80	10.28	14.8	6.7	8.4	10.1	28
90	11.44	18.0	7.5	9.4	11.2	14
100	12.6	20.7	8.2	10.3	12.4	0
110	13.8	18.7	9.0	11.3	13.5	0
120	14.9	17.4	9.7	12.2	14.6	0
140	17.2	14.8	11.3	14.1	16.9	0
160	19.6	12.9	12.8	16.0	19.3	0
200	24.2	10.3	15.8	19.8	23.8	0
250	30.0	8.3	19.6	24.5	29.5	0
300	35.9	6.9	23.5	29.4	35.1	0
400	47.4	5.2	31.0	38.8	46.5	0

Col. I from Col. III, Table 1.
Col. II from Col. VIIIb, Table 1.
Cols. III, IV, V = Col. I $\times$ .2375 $\times$ $(t^1 - t^0) \div 14{,}500$.
Col. VI = (14,500 — Col. IV, Table 2) $\div$ 14,500.
Computations by 10-inch slide rule.

TABLE 3. COMBUSTION LOSSES AND CO_2 PERCENTAGES, PERFECT MIXTURE.

Where there is a deficiency of air supply, the production of carbon monoxide, evolving 4,400 B. T. U. instead of 14,500 B. T. U., results in a loss of 69.6 per cent. The proportion of carbon which burns to monoxide being twice the air deficiency, we have for any stated deficient percentage of air, p, a loss of heat which may be expressed by $2p \times .696$. When, however, the air supply is below 50 per cent of the theoretical, only a portion of the carbon can be burned, even to monoxide, and from zero to 50 per-cent air supply the proportion of carbon thus burned rises by increments in accordance with the augmentation of air supply. The proportion of monoxide was thus calculated in Table 1, the total heat generated per pound of carbon being given in Column IV, Table 2. The loss of heat, below the full calorific value of 14,500 B. T. U., and the corresponding percentages of CO_2, when combined with the loss of heat to the flue gases, give the dotted curves of Chart II, showing that identical percentages of CO_2 indicate greater heat loss when monoxide is present than when it is not present.

It will be noted that equal increments in percentage of dioxide represent much wider differences in economy at the lower ranges of

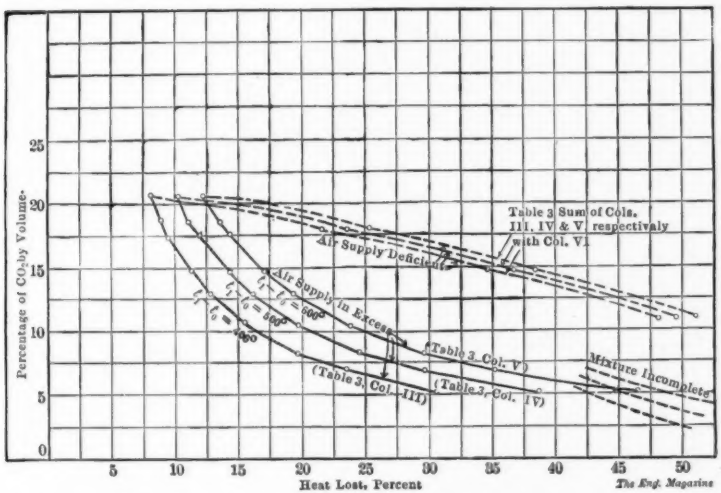


CHART II. LOSS OF HEAT AS INDICATED BY PERCENTAGE OF CO_2 IN FLUE GASES.

Showing relations corresponding with percentages in the table opposite.

efficiency than at the higher. The rise from 3 to 6 per cent of carbon dioxide represents a difference in fuel consumption of about 23 per cent, while as between 15 and 18 per cent of dioxide the difference in fuel consumption is only about 2 per cent. The extreme significance of even very slight variations in percentages of dioxide, when that percentage is low, is evident. No possible measurement that can be made at any point of power-plant operation can give such startling results as this. To make the impression still stronger, it should be remembered that the loss increases, directly with the percentage of air; while the percentage of dioxide in the gases—a maximum at about 20 per cent with the theoretical amount of air—is halved every time the air supply is doubled. At maximum dioxide and minimum air the loss of heat to the stack is about 10 per cent. If the dioxide is halved, the loss is 20 per cent; if dioxide falls to 5 per cent, the loss is 40 per cent; for 2½ per cent of dioxide the loss is 80 per cent.

These approximate figures will appeal to the coal buyer, particularly in view of the fact that as low as 2½ per cent of dioxide is not infrequently found. It is not a difficult matter, with proper facilities, to reach 10 per cent of dioxide, corresponding to a heat loss of 20 per cent. If we assume that such a loss represents proper

operation, then in plants obtaining lower percentages, the following amounts of fuel are being wasted:

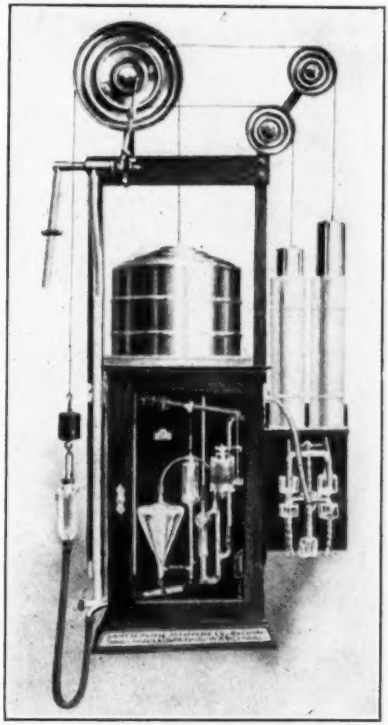
Per cent. of CO_2.	($t' - t° = 500°$) Percentage of fuel wasted as compared with 10 per cent. CO_2.
9	2½
8	5
7	8¼
6	13½
5	19½
4	29
3	45

In general, we may express these figures approximately by the formula $200 \div p = P$, in which p = percentage of dioxide in the flue gases, P = percentage of total heat lost to the stack. The calculations on which these figures are based involve several assumptions, which will be discussed later. These assumptions do not, however, modify the figures above given to any such extent as to invalidate their general relation or diminish their suggestiveness. It cannot be too strongly impressed upon the power-plant owner that CO_2 is the factor upon which depends his very existence under any circumstances of real competition.

Remarkable boiler and furnace efficiencies have been obtained in the Western States by plants using California oil as fuel. This is the more noteworthy because the coal and wood-burning power plants of the same region have been rather noted for operation quite the reverse of economical. The reason for the improvement, with oil, is that oil fuel presents peculiar opportunities not only for economical general operation, but particularly for economical control of air supply and consequent high percentages of dioxide. The oil can be regularly and easily measured at slight expense; its quality is almost exactly uniform; its combustion can be regulated with great nicety, and the conditions of combustion kept constant. There is no opening fire-doors every two or three minutes; no cleaning of fires and consequent cooling of furnaces accompanied by a large influx of cold air; no damage to grate bars and brickwork resulting in a necessity for unfavorable operation until the regular shut down. One of the first steps taken when coal or wood furnaces were altered for oil fuel was to brick over the greater part of the grate, cutting down the air space to a small fraction of what it had formerly been. In addition to this, the ash-pit doors were kept nearly closed and the dampers given much closer attention. The result has been not only a large increase in boiler efficiency, but a general increase in boiler capacity of 30 or 40 per cent, due to the higher temperature of furnace maintained.

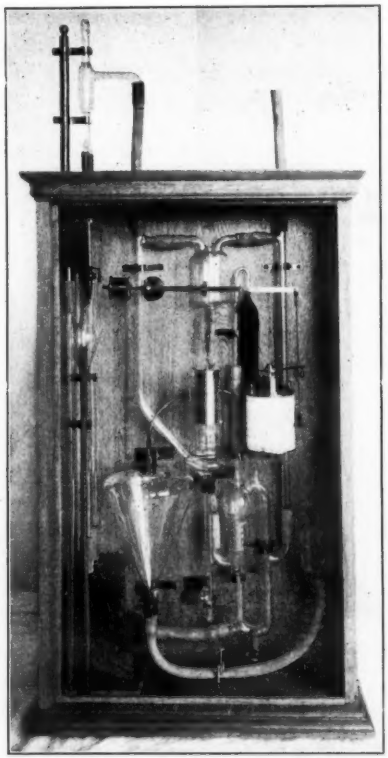
Premising therefore, the absolute necessity of close observation of air supply by means of gas analysis, it is obvious that methods of quickly, accurately and continuously indicating and recording the composition of flue gases, or at least the percentage of carbon dioxide, are of the highest importance.

Various forms of apparatus have been devised to facilitate this work. The Orsat and Hempel equipments have been used with good results for a number of years. They are accurate, but are suitable for experimental work only, giving the composition of a single sample of gas after a sequence of operations which involve a considerable amount of time. In default of anything better, they will answer. Where so large an opportunity for loss exists, the cost of manipulating the apparatus cannot be considered.



SARCO AUTOMATIC CO_2 RECORDER.
Courtesy, Sanders, Rehders & Co., London.

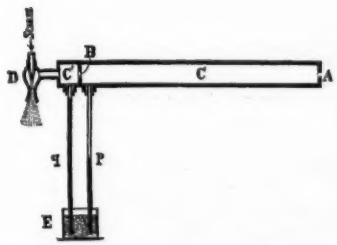
Within the last few years, in view of the urgency of the subject, there have been introduced at least three types of apparatus which more or less automatically and continuously determine the percentage of carbon dioxide in flue gases. One of the best known of these is Arndt's Econometer. This instrument consists essentially of a delicate chemical balance which is connected so as to trap and accurately weigh a known volume of the flue gases. As carbon dioxide is much heavier than oxygen, nitrogen, or the monoxide, the weight of the sample is an index to the amount of dioxide in the sample, and a graduated scale is provided along which a pointer moves, giving percentage readings direct. The instrument does not record its readings. It is inaccurate to a small degree on account of the difference in density of oxygen and nitrogen or carbon monoxide; but as the percentage of oxygen under good operation is very low, the inaccuracy does not greatly affect the results.



ANALYZING AND RECORDING PORTION OF THE SARCO APPARATUS.

Sarco Fuel Saving & Engineering Co., New York.

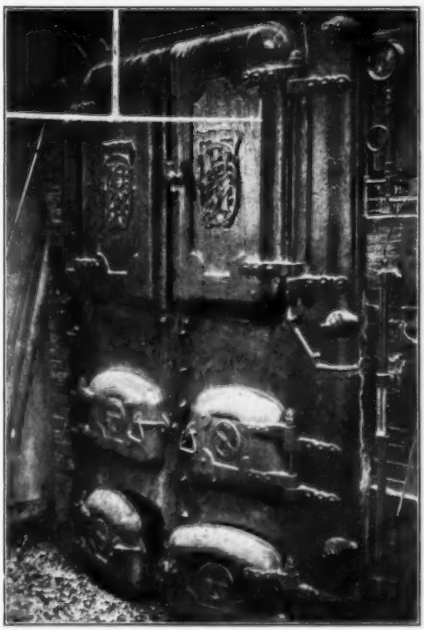
The "Sarco" Automatic CO_2 Recorder is illustrated herewith. The large cylinder at the back of the cabinet (page 427) is the "motor" or operating device, actuated by means of draft from the chimney. This cylinder (of sheet brass) is an inverted bell, floating in a tank of water. The tank has an internal cylinder rising from the bottom to a point above the water level, into which a tube enters from the flue. The suction in the flue produces a vacuum over the water and under the bell, causing the latter to descend. When it has reached the lowest point of its stroke, a valve is automatically opened admitting air under the bell, which consequently rises until the valve is automatically closed at the top of the stroke and the suction from the flue once more causes the bell to descend. The slow reciprocating motion thus obtained is utilized to operate the two pumps shown at the right of the cabinet, which suck the gases from a point in the flue near the damper and deliver them to the registering apparatus inside the cabinet. This registering apparatus is arranged to trap a fixed volume of gas at a constant pressure, which trapped portion of the gases is then brought into contact with a 27 degree solution of caustic potash. The potash absorbs any carbon dioxide present, and the remaining gas passes under a small bell which operates a counterbalanced pen tracing a line on a chart operated by clockwork. The pen is so adjusted that when no dioxide is present, the stated volume of gas will cause it to rise to the zero point of the chart. If dioxide is present, its absorption by the potash results in a decreased volume of gas, and the pen does not rise so high, the least rise occurring for the highest percentage of dioxide.



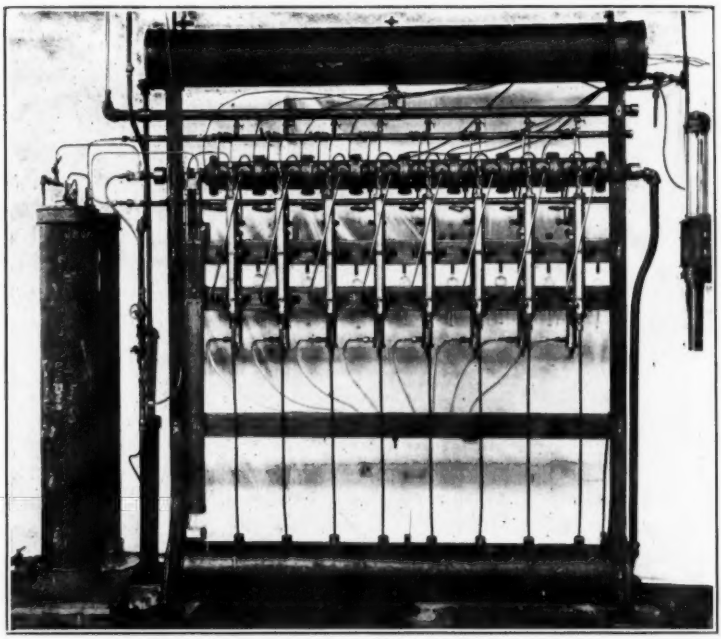
SHOWING OPERATING PRINCIPLE OF THE UEHLING GAS COMPOSIMETER.

This apparatus requires some attention, as variations in the temperature of the potash, etc., introduce irregularities; but under proper supervision it gives reliable results, which may easily be confirmed by devices furnished with the instrument, or by independent analysis. One analysis of the gas is made at each revolution of the "motor" or operating bell; and as the absorption of dioxide by the potash is a process involving some time, the operation should not be faster than one revolution in every ten or fifteen minutes. This, of course, gives an intermittent record, only: and the instrument "indicates" the results only at that instant when the cycle of operation is completed; or say once every ten or fifteen minutes.

The Uehling Gas-Composimeter is based on the law governing the flow of gas through small apertures. In the diagram on this page if a vacuum be produced in C, air (or gas) will flow from C through the aperture B, and the vacuum thus produced in C will produce a flow through A. If the apertures B and A are of the same size, the vacuum in C will be about half that in C', so long as the same volume of gas is flowing through B as through A. If, however, a constituent of the gas be continuously removed therefrom, while it is passing through chamber C, the vacuum in that chamber will be correspondingly increased. The increase of vacuum in C



INDICATING GAUGE OF UEHLING COMPOSIMETER INSTALLED IN FIRE ROOM.



UEHLING GAS COMPOSIMETER, MULTIPLE FORM.
Can be installed thus up to 12 units in one system. Uehling Instrument Co., Passaic, N. J.

as shown by a manometer therefore indicates the volume of gas absorbed. In the instrument which has been developed by the Uehling Instrument Company, it is attempted to produce, as nearly as possible, the conditions necessary to preserve the correctness of these indications. The operation is absolutely continuous and the instrument at all times indicates the percentage of dioxide in the gas passing through it, in addition to furnishing a continuous chart showing the variations. The indicating device can be installed, if desired, at a considerable distance from the rest of the apparatus. This is an advantage, as it permits of providing an indicating gauge where the fireman can see it. Excepting the recorder, this apparatus has no moving parts. All these flue-gas analyzing devices are rather expensive and somewhat delicate, and with all of them the methods of sampling the gases are of the first importance; but, as has already been said, the stake is so large that no steam producer can afford to hesitate at the expense or the complication necessary to secure proper combustion.

THE DESIGN OF MODERN PRODUCERS AND GAS ENGINES.

By R. E. Mathot.

The constantly rising pressure of competition from the gas engine is admitted on all sides to be the greatest influence now operating to urge makers of steam machinery on to further betterments in efficiency and economy. Mr. Mathot is known internationally as a leading expert in all matters pertaining to the construction and installation of internal-combustion motors. He presents some of the latest important data and studies in this field, as Mr. von Schon and Mr. Ennis, elsewhere in this same issue, do in the case of the steam plant and the hydro-electric installation, respectively. A following article, next month, will deal with the latest principles of gas-producer design.—THE EDITORS.

SINCE the large gas engine has attained its present enviable position in industrial operation, the rules governing the construction of the internal-combustion engine seem to have undergone considerable change. From the practical knowledge acquired in constructing large steam engines, the makers of the former type of prime mover have derived valuable suggestions; in fact, a great many of the largest fuel-gas engines, such as those using coke-oven and blast-furnace gas, are turned out of shops which were formerly devoted, almost entirely, to the construction of large steam engines.

So far as general principles are concerned, it must be realized that there is no reason whatever why the substitution of an explosive mixture for steam should cause any material difference in the construction of prime movers. In both cases, we must secure perfect steadiness in the engines and we must also protect them against ruptures of the important parts liable to uneven expansion caused by high temperatures. Steadiness is obtained by the use of heavy and bulky frames which constitute large metallic seats, so shaped that they can be strongly bound to the masonry of the foundations. The use of superheated steam at a temperature as high as 350 degrees C., has enabled engineers to discover the weak points in the design of large engines with regard to expansion. Owing to their great length, tandem steam engines have afforded many valuable suggestions in gas-engine design. In the latter, the tandem arrangement is even more suitable than it is in steam-engine construction, since it affords the realization of a greater cyclic regularity than is possible in single-cylinder engines. It is, moreover, a necessary condition for the attainment of high powers like 700 to 1,000 horse power, which are rarely surpassed nowadays with a double-acting single cylinder.

The application of the principle of the double-acting cylinder to internal-combustion motors has led to the use of piston rods, crossheads, and guides, and this has given rise to the difficulties encountered with large, tight stuffing-boxes with which steam engineers have already had long experience. As a consequence of the adoption of the system of admission and exhaust by means of valves at the ends of the cylinder, as in the steam engine, the admission valves have been located at the top, and the exhaust valves at the bottom of the cylinder, the latter also acting as natural drains for the waste oils. The new systems of governing by varying the quantity of explosive mixture admitted to the cylinder, have led to the use of powerful governors protected against the prejudicial reactions on the part of mechanical devices interfering with the governing. The necessity of even and thorough lubrication of large and heavily loaded rubbing surfaces, even at the high temperatures attained in superheated-steam cylinders, brought before engineers a problem which has been solved successfully by the forced oiling and recuperation system, a device which has been successfully applied to large gas engines also. In short, it is evident that the principles involved in a great many features of the construction of large, superheated-steam engines, can be applied, to advantage, to gas-engine design.

Besides the technical principles, there are, of course, some commercial requirements that must not be overlooked. A consideration of the keen competition existing among makers of small gas engines, which has forced the cost of these motors to the lowest possible point, will show the importance of the commercial aspect of the question. Therefore, I shall endeavor to point out the limits of power within which one or another of the several arrangements, hereinafter described, ought to be applied, according to my experience and the shop rules of the leading firms with which I am connected.

It must be borne in mind that, whatever the power of the engine is to be, the gas motor must be designed to compete with the steam engine, and must be able to last, like the latter, for at least eight or ten years without requiring monthly repairs. One of the unfortunate features of ordinary gas engines of the stationary type, is the fact that many of these motors require monthly repairs after the first two or three years of use. Notwithstanding the amount that has been written on the subject by people more or less interested in the gas-engine and producer, who are, owing to that very fact, perhaps a little too enthusiastically in favor of that type of prime mover, it must be confessed that safety in working, facility of control, and cheapness of upkeep, are, so far, much better realized in the steam engine than in

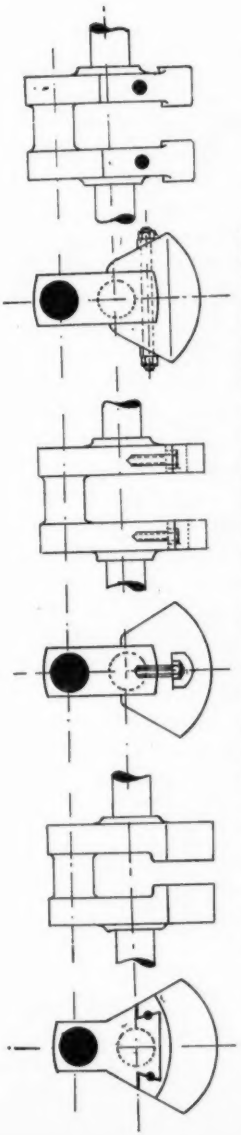


FIG. 1, 2 AND 3. METHODS OF ADJUSTING COUNTERWEIGHTS TO CRANK-SHAFT WEBS.

the modern gas engine. This is not surprising if one considers the very long history which the steam engine has behind it in comparison with that of the gas-engine. In spite of youth, however, the gas engine has made remarkable progress and it may be stated that the attainment, in the gas engine, of the working conditions of its old rival, will place the former in a position much nearer perfection than the latter, notwithstanding the claims to the contrary of makers of the steam engine.

Considering the gas engine in itself, regardless of the origin, or system of production, of the gas with which it is fed, it is obvious that the failures in working are due mainly to faulty design or defective mechanical appliances. I shall, therefore, endeavour to indicate some of the main rules and principles of construction that are now generally applied after successful use.

Ignition.—Ignition should be obtained by electro-magnetic apparatus exclusively, for engines above 20 horse power, as well as for any engine below this power if fed with producer gas. The electro-magnetic gear should be provided with a contrivance allowing the regulation of the point of ignition during the working of the engine. This should consist of a mechanical device with rods or spindles, as light as possible in order to afford a quick and sharp "break and make" not affected by the inertia due to an excessive weight or bulk of moving parts. The plug carrying the contacts must admit of being easily dismantled for the removal of any working part near it. For one-cylinder engines of more than 100 horse power, two separate and independent ignition devices, each having a magneto, should be used.

Crank-Shaft.—The crank shaft should be made of the best quality of mild steel. The webs should be machined out of plain metal. Counterweights should be firmly adjusted to the webs for any size of engine above 15 horse power (Figures 1, 2 and 3). During working, no kind of side movement should be allowed in the flywheels as a consequence of the flexion of the crankshaft at the time of explosion, and not even under pre-ignition. The shaft, at the journals, should be provided with a projecting ring, machined in the metal and acting as oil catcher, in order to avoid the withdrawal of oil on the flywheels, pulleys, or crank-shaft webs (Figure 4).

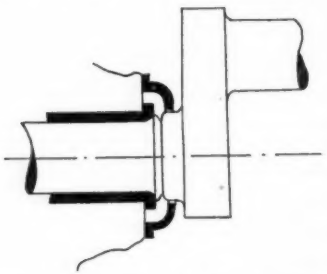


FIG. 4. OIL RING FOR SHAFT JOURNAL.

Air Suction.—This can be effected by means of air-ports, either independent or in the frame of the engine itself, though for town-gas engines the first contrivance is to be preferred. The number, shape and sections of the air passages should be designed to avoid abnormal noise or whistling. The air pipe should be provided with a valve or throttle for regulating the air supply, located close to the inlet.

Bed Frame.—This should be provided with a groove at the bottom for collecting the waste lubricating oil (Figure 5). It is preferable that the frame should be so designed that the foundation bolts pass right through the casting to secure a more rigid attachment to the masonry. The cylinder jacket should be cast in one piece with the frame and after such a design as to afford the least possible overhang.

Cams and Rollers.—These should be made of cast iron, or of the best, hard-quality steel. They should be case-hardened 1/16-inch deep and mechanically rectified.

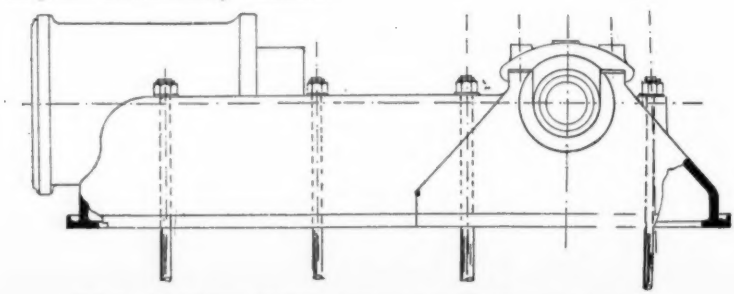


FIG. 5. BED FRAME, SHOWING MINIMUM OVERHANG OF CYLINDER.

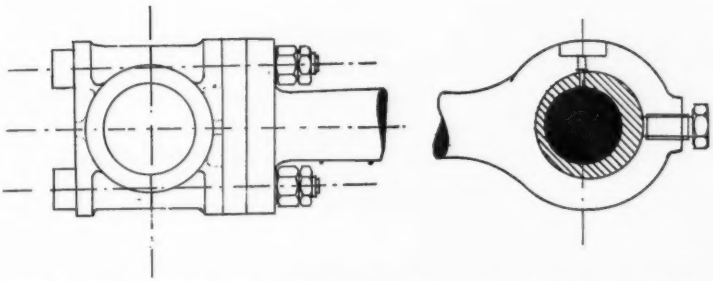


FIG. 6 AND 7. CONNECTING-ROD BEARINGS FOR ENGINES BELOW 30 HORSE POWER.

Bearings and Guides.—These should be bushed with brass or babbit metal. Their design should permit easy adjustment for wear and tear. For single-cylinder engines of above 100 horse power, side shaft-bearings should be provided with ring lubrication.

Connecting Rod.—The connecting rod should be of mild cast steel. For engines below 30 brake horse power, the head bearing may be of the marine type (Figure 6), of gun metal, and the foot bearing may be made with independent bushes held in position by a set screw (Figure 7). For larger engines, the head of the connecting rod should be cut and turned out of plain metal, then split and adjusted with bolts. For securing an accurate fit, copper foil should be fitted between the two parts of the covers. The brasses should be made in two parts, with cast-steel shells lined inside with babbit metal (Figure 8). The foot bearing should be cut out of the metal and fitted with brasses of good bronze (Figure 9).

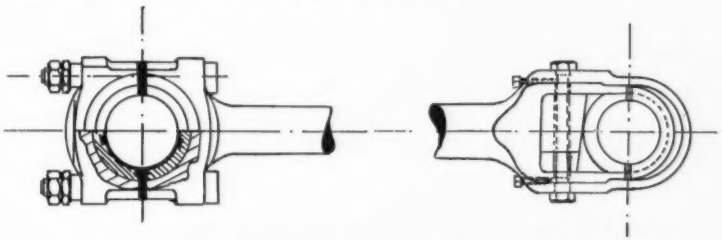


FIG. 8 AND 9. CONNECTING-ROD BEARINGS FOR LARGE GAS ENGINES.

Cylinder Heads.—For high-compression engines (above 100 to 110 pounds) of more than 600 horse power, the cylinder head should be provided with a separate and independent water supply and outlet pipe for cooling. The exhaust pipe also should be partially water-jacketed. In all suitable parts provision should be made for large openings in view of easily removing the core after casting and also

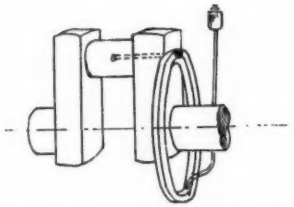


FIG. 10. CRANK-PIN LUBRICATION.

of securing a thorough cleaning of the inner walls and removal of the scale and lime deposits.

Cylinder.—The cylinder should be provided with an independent lining of very hard cast iron. An indicator hole should be located in an accessible part and provided with a ¾-inch Whitworth tap. The indicator hole should be closed by means of a spindle, the inner end of which should be level with the lining, in order to avoid any accumulation of gas in the canal.

Lubrication.—All the rubbing surfaces should be automatically oiled by continuous sight-feed lubricators. The lubrication of the crank pin or connecting-rod head should be provided by means of a centrifugal ring fixed on one of the crank webs and provided with a suitable plug to allow cleaning (Figure 10). The piston pin should be oiled with an independent sight-feed lubricator of the wiper type (Fig. 11). The piston should be provided with a visible and adjustable supply of oil, by means of an oil-pump forcing the oil under pressure; this pump should be positively driven from the engine, any mechanical device except a system of pulleys and belts which are liable to slip being satisfactory. The pump should be designed for both hand and mechanical operation in view of allowing lubrication of the piston prior to starting the engine. The tank supplying the oil to the pumps should be provided with a gauge glass indicating the amount of its contents. The bottom of the oil tank should be provided with a filter to prevent dust or rubbish from getting into the cylinder. The end of the inlet pipe should be provided with a sight-feed and a check valve to allow for easy dis-

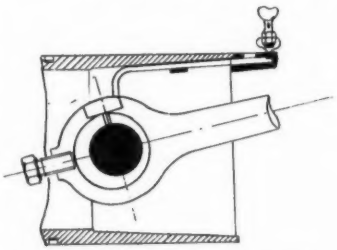


FIG. 11. PISTON-PIN LUBRICATION.

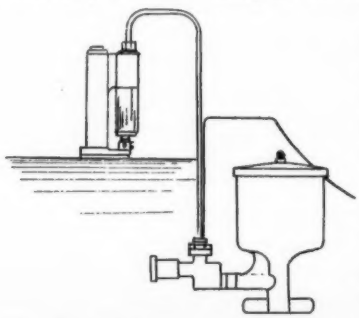


FIG. 12. SIGHT FEED AND CHECK VALVE ON OIL PIPE.

mantling during the working of the engine in case of obstruction (Figure 12). The capacity of the oil cups or reservoirs should be sufficient to ensure the lubrication of the several parts for at least five hours working under full load without having to renew the oil.

An oil gauge with a drain cock should be fitted to the oil tank which should be deep enough to allow free deposit of the dirt. The spindles of the gas- and air-inlet valves and more especially, the spindle of the exhaust valve, should be provided with an efficient and easily controlled oiling device.

For engines ranging from 25 to 30 horse power, the main bearings of the crank-shaft should be of the ring-lubricating type with a single ring and should have plain bronze brasses; the cover may be held by two studs and double nuts (Figure 13). For larger engines ranging from 45 to 50 horse power, two rings should be used for each bearing and four studs for holding each cover. The bushes should be steel shells lined with babbit metal.

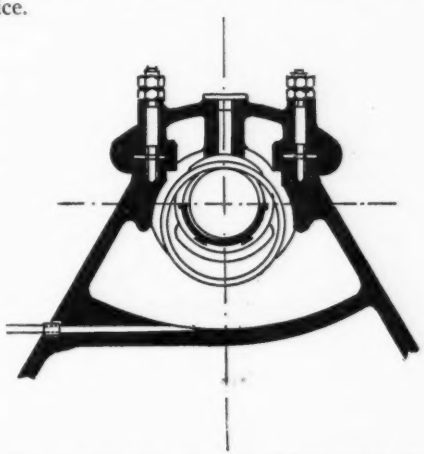


FIG. 13. BEARINGS AND CAP, ENGINE BELOW 30 HORSE POWER.

Joints.—All joints necessary in the several parts of the cylinder head or the combustion chamber should be "dry," the metal surfaces being directly ground and of such a design that regrinding shall be possible after the installation of the engine.

Piston.—The piston should be provided with at least five soft cast-iron rings for engines below 20 horse power and with at least six rings for higher powers. The piston pin should be of the best-quality steel, case-hardened 1/16- inch deep and it should be rectified on the grinding mill. The pin should be secured in only one boss, by means of one or two set screws. The use of wedges or clamping screws liable to work loose and injure the cylinder must be avoided.

Governor.—The governor may be of the inertia type for "hit and miss" engines under 15 horse power. Above this power the governor should be of the centrifugal type. The governor should be sufficiently sensitive and efficient to limit the variations in the number of revolu-

tions, between full load and idle running, within 3 per cent if the engine is governed by hit and miss, and 5 per cent if the engine is governed by variable admission. Belt-driving should not be admitted and worm gears are to be preferred to bevel gears. In the case of variable admission, steadiness of the governor should be obtained by means of a dash-pot or oil piston, provided with a proper arrangement of the by-pass to allow regulation without stopping the engine. A set spring should also be fitted to the governor to regulate the speed within the limits of 5 or 10 per cent of the regular number of revolutions of the engine.

Regulation.—Governing by variable admission of a constant ratio of mixture is preferable in engines above 50 horse power when fed with producer gas and should be applied in any case to engines above 25 horse power when fed with town gas.

Valves.—The valves should be easily accessible and located for easy dismantling with a view to quick and thorough cleaning. They should be mechanically operated except in the case of arrangements similar to that of the Koërting mixing valve. The spindles should be fitted with oiling tubes; for engines above 50 horse power, these tubes should be fitted with sight-feed oilers, with a view to preventing fouling of the spindles or abnormal wear. That of the exhaust valve must be well cooled by water circulation. The spindle and its mushroom should be machined in one piece out of plain steel.

Rubbing Surfaces.—The surfaces of all friction parts should be made sufficiently large to prevent heating and wear. The following table of intensity of thrust should be applied in calculations of surfaces. An initial explosive pressure of 350 pounds per square inch of piston area is taken as a basis.

	Pounds per square inch.
For the piston pin	3,000
For the crank-shaft journals	600
For the crank-pin	1,600

This thrust is considered as relating to the projected surface, i. e., diameter multiplied by length.

Flywheels.—These should be accurately turned and set at the rim and at the boss. For engines of the "electric type," the rim should be slightly rounded to carry a belt for driving the dynamo. The rim velocity, in this case, should not exceed 500 feet per minute. The projecting parts of the keys or key ways should be protected by an envelope or cap fitted around the shaft. When the weight of the flywheel exceeds 4 tons, it should be provided with a moving gear

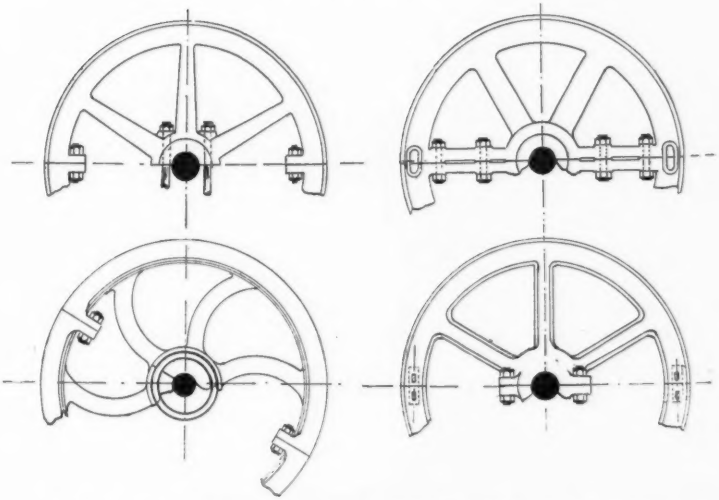


FIG. 14 TO 17. METHODS OF BOLTING TOGETHER THE HALVES OF FLYWHEELS.

which renders it possible for one man to put the flywheel at the starting point. For engines of the "industrial type" of less than 30 horse power, the crankshaft may be provided with one or two overhanging flywheels. In larger engines as well as in the "electric" types of driving dynamos, there should be a single flywheel supported by a third external bearing. In such a case the driving pulley should be fitted between this bearing and the flywheel. This pulley should be cast in two pieces. For engines above 50 horse power the flywheel should be in two halves joined together by bolts and hoops at the boss and at the rim in accordance with a design similar to any one of those shown in the accompanying illustrations (Figures 14, 15, 16, and 17).

When arranging a gas engine to drive a constant-current dynamo, it must be remembered that the current supplied to incandescent lamps should insure a light of perfect steadiness, without the necessity of making use of accumulators, no matter what power between 1/3 of the full load and the full load, is developed. Under these conditions, the engine must have such a cyclic regularity as to prevent variations of more than 2 per cent in the readings of aperiodic ammeters or voltmeters. The allowable amount of variation in a single revolution of the fly-wheels is as follows:

For ordinary industrial purposes.....	1/25 to 1/30
For electric lighting by continuous current.....	1/50 to 1/60
For spinning mills and the like.....	1/120 to 1/130
For alternating-current generators in parallel.....	1/150

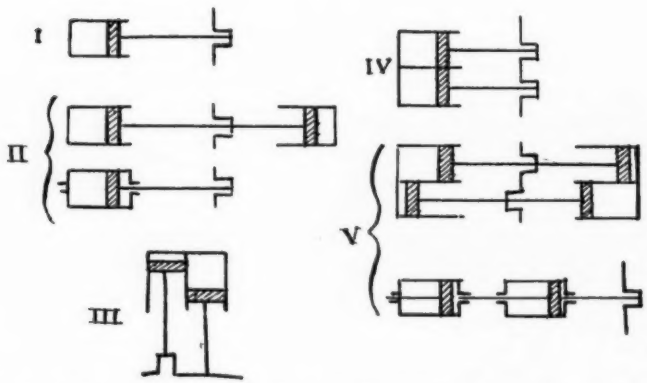


FIG. 18. DIAGRAM SHOWING CYLINDER ARRANGEMENT FOR THE TYPES OF ENGINES BELOW.

The following formula should be applied for the determination of the dimensions of the fly-wheels of the different types of engines.

$$P D^2 = K \frac{N}{a n^3},$$

hence

$$P = K \frac{}{D^2 a n^3},$$

in which

P = the weight of the rim (without arms or boss) in tons;
D = diameter of the centre of gravity of the rim in metres;
a = the amount of allowable variation;
n = the number of revolutions per minute,
N = the number of brake horse power,
K = coefficient varying with the type of engine.

I K = 44,000 for Otto-cycle engines, single-cylinder, single-acting.

II K = 28,000 for Otto-cycle engines, two opposite cylinders, single-acting, or one cylinder double-acting.

III K = 25,000 for two cylinders single-acting, with cranks set at 90 degrees.

IV K = 21,000 for two cylinders, single-acting.

V K = 7,000 for four twin opposite cylinders, or for two tandem cylinders, double-acting.

The total weight of the fly-wheel is P x 1.4. For diagram showing the arrangement of cylinders, see Figure 18.

BOUNDARY CREEK, FROM WHICH THE COPPER DISTRICT TAKES ITS NAME.

METHODS OF MINING IN THE BOUNDARY DISTRICT, BRITISH COLUMBIA.

By Frederic Keffer.

The great demand for copper caused by the growth of the engineering industries, especially by the enormous increase in the development and use of electric power, has stimulated the production of the metal to the utmost. One of the most interesting phases of this increase has been the profitable mining of ores so low in grade that formerly they would have been ignored as valueless. This success has been attained only by the introduction of methods devised by the highest skill and ingenuity, and it is most appropriate that these should be described by a mining engineer who, like Mr. Keffer, has taken part in the work and is today successfully prosecuting it. His article in this number on the mining methods will be followed by another dealing with the subsequent treatment of the ore.—THE EDITORS.

THE Boundary Creek mining district of southern British Columbia includes, generally speaking, the country between the North Fork of the Kettle River on the east and the main river on the west, and from the International boundary to some 25 miles north. The creek from which the district takes its name occupies a valley about midway between the two branches of the Kettle River, the creek itself entering the Kettle River on the International boundary, whence its name. The country, though mountainous, is not rugged; the hills seldom reach a height above 6,000 feet, and are rounded by heavy glaciation and erosion.

GENERAL VIEW OF THE MOTHER LODE MINE, DEADWOOD CAMP.

The mineral deposits may be divided into two main classes. The first consists of narrow veins occurring in fissures within granite rocks or between the contacts of these rocks and adjoining greenstones; these veins contain usually lead, iron, and zinc sulphides together with high values in gold and silver. The gangue rock is usually very silicious. The second class includes deposits of irregular form and frequently of enormous extent, containing copper as chalcopyrite ($CuFeS_2$), iron sulphides as pyrite or pyrrhotite, and iron oxide as magnetite; the gangue minerals being mostly calcite, quartz, garnetite, epidote and greenstones. These ores carry 1 to 3 per cent of copper, and from $1 to $3 in gold and silver. It is the mining of these latter ores which forms the subject of the present paper.

In Deadwood Camp the largest ore body, (that on the Mother Lode claim) lies between limestone on the west and greenstones on the east, and dips east at an angle of approximately 70 degrees.

The origin of the ore is apparently to be found in replacement of both limestone and greenstone by ascending mineral-bearing solutions. In Phoenix Camp, the enormous ore bodies appear for the most part to be volcanic ash beds, subsequently mineralized by copper-bearing solutions. These beds have usually dips of from 35 to 70 degrees, and often lie roughly parallel to the slope of the containing hills. In Summit Camp the Oro Denoro deposit is probably similar in origin to those of Phoenix and lies approximately parallel to the slope

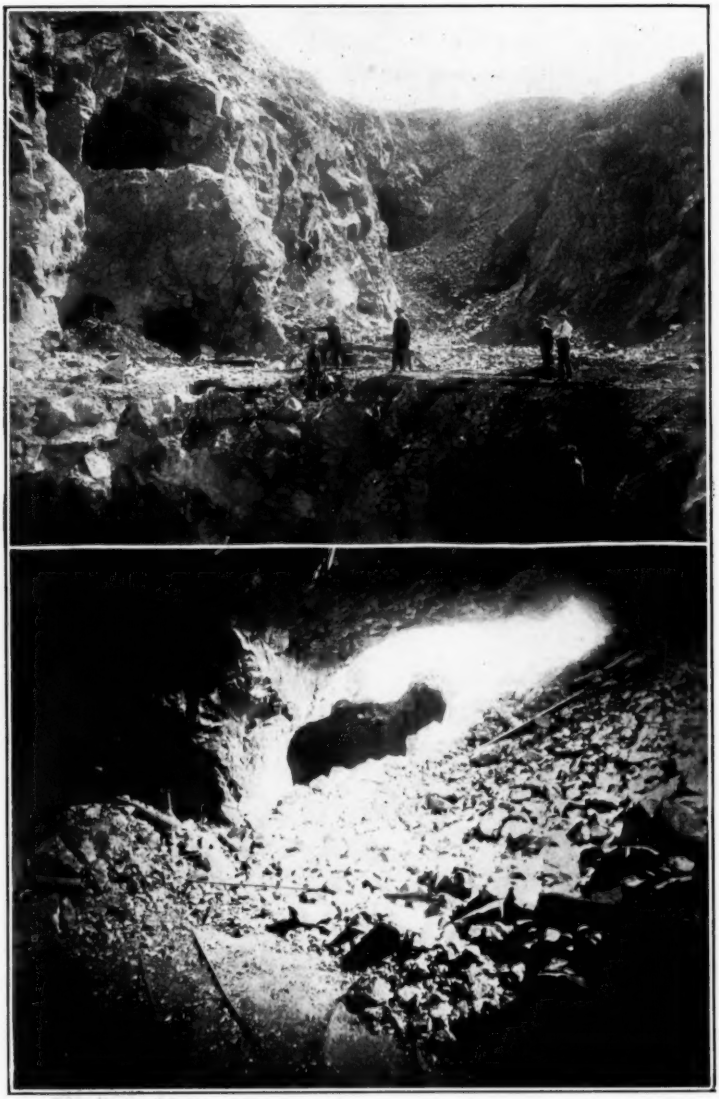
of the hill, while the ore on the adjoining claim, the Emma, is between the contact of lime and greenstones, and stands vertical.

There are as a rule no definite walls to the ore bodies, the mineralization fading gradually away into the country rocks. Limestone contacts, however, are generally sharper than greenstone ones, the limestone appearing to have been more impermeable to the mineralizing solutions. The walls are thus really commercial ones, being the points where it does not pay to mine the ore further; and naturally the price of copper will to some extent govern the positions of the walls. Ore bodies are frequently separated by wide zones of entirely barren rock, and this, coupled with their irregular forms, has led to the general adoption by the larger mines of diamond drilling as a means for locating new deposits. Great dykes of alkali porphyry frequently accompany the ores, sometimes presenting to the miner problems of ore extraction which puzzle his ingenuity to the utmost to solve.

These stratigraphical features are briefly summarized here inasmuch as they have an intimate bearing on the mining of the ores, as well as on their discovery through development operations.

Four general conditions have contributed to the successful mining and smelting of these low-grade ores, the absence of any one of which would render their working nearly or quite unprofitable. These conditions are: (1) the enormous extent of the ore bodies, making

GENERAL VIEW OF THE GRANBY MINE, PHOENIX, B. C.



THE GLORY HOLE, AND UNDER THE GLORY HOLE, GRANBY MINES, **PHOENIX.**

mining on a huge scale possible; (2) the solidity and firmness of the ground which makes the opening of great stopes without the use of timbers not only feasible but also safe; (3) the chemical composition of the ores which, through rendering them self-fluxing, obviates the use of any barren fluxes; and lastly (4) the proximity of the district to the vast coking-coal fields of the Crows Nest Pass.

Other contributing though not essential aids are abundant electric power, plentiful water and timber, dry mines requiring little pumping, and an unsurpassed climate.

The methods employed in mining may be classed as follows:

1.—Open pits or "glory holes."

2.—Rock pillars and stopes.

3.—Timbering sill floors under stopes: (a) wholly, (b) partially.

Glory Holes.—This method of ore extraction is feasible only where the overburden of soil or barren rock is not too great, and is best carried out in mines where the dip of the ore deposit is high; otherwise the perpendicular wall of the glory hole on the hanging-wall side of the ore will quickly intercept the foot wall, making the pit come to a point; and it is not practicable for reasons of safety to follow the ore in an open pit underneath the hanging wall.

In opening up the deposit for glory-hole work, a tunnel or drift is run under the ore at a depth if possible below the point where the perpendicular wall and foot wall will come to a point. Raises are now run near the foot wall from this tunnel or drift or from its branches, to the surface, which raises are provided with chutes at the bottom. Having filled the raises with ore the rock can then be blasted around their collars, funnel-shaped openings being formed which grow deeper and wider as the work progresses; care must be taken to keep the raises full of ore so as to prevent big rocks from getting into them, thus choking the chutes. The drill holes are run from 6 to 20 feet deep, and before being blasted the deeper ones are "chambered" by exploding several sticks of dynamite at their bottoms; when the holes have cooled off, for which abundance of time is allowed, the chambers are filled with dynamite, often as much as 25 to 50 pounds to a deep hole, and fired. Usually but one or two deep holes are blasted at a time so that the broken ore may be properly "bulldozed", which operation consists in breaking the boulders of ore by exploding 60 per cent dynamite on top of them, the dynamite being covered with fine ore or sand. If the boulders are very large, they are "block-holed" with a "baby" drill, or often with a light pneumatic hammer drill. Although one stick of dynamite exploded inside a rock is much

more effective than several exploded on top of it, it does not pay to block-hole any but the larger boulders, the powder being less costly than the labor, when breaking small rocks. By keeping the sides of the tunnels sloping about 45 degrees the ore may be carried into the raises with little or no shoveling, a very important saving thus being effected. Instead of the ore being funneled into the raises, it is sometimes loaded in cars and dumped into them; the Granby Company at Phoenix successfully used steam shovels in one of its glory holes, loading the ore in dump carts for transportation to the raises.

It is important to cool the chambered holes before reloading, nor should these holes in ores carrying high percentage of lime be cooled by water prior to loading. One severe accident came under my notice which could be traced to no other cause than the heating of a cold chambered hole through the action of water on the quick-lime produced by the burning powder during the chambering process. In this instance it was thought to make the hole surely safe by pouring in cold water prior to loading, but apparently the reverse effect was obtained.

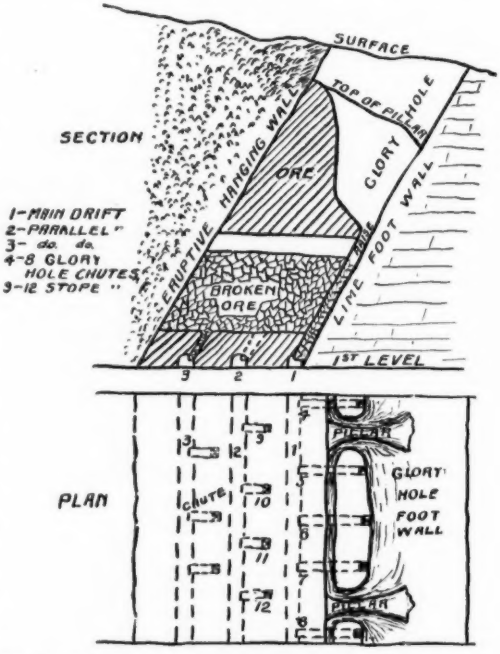


FIG. 1. PLAN AND SECTION ABOVE FIRST LEVEL IN MOTHER LODE MINE, SHOWING GLORY HOLE AND STOPE.

Figure 1 is a cross section of one of the glory holes at the Mother Lode mine, which illustrates the general plan followed.

Rock Pillars and Stopes.—Owing to the low dip of many of the deposits, it is evident for the reasons stated above that the period of glory-hole work is necessarily limited, and that sooner or later under-

ground mining must begin. Square-set timbering being out of the question on account of its prohibitive cost, the usual plan is to open stopes above a roof supported by pillars of ore.

Owing to the great irregularity in form of the deposits each section of the work, even in the same mine, must be treated individually and plans made to suit the form and dip of the ore contained in that section. In mines where the dip of the ore is over 60 degrees, as in the Mother Lode, it is the practice to run two or three or sometimes even four approximately parallel drifts under the ore to be extracted, the number depending upon the width of the ore body. From these drifts raises are run at intervals of about 30 feet, these raises being provided with timbered chutes at their bottoms, the chute openings being usually 4 by 2½ feet in section and lined with ¼-inch steel plate. About 10 to 12 feet over the backs of the drifts, stoping is started in the various raises and ultimately all the growing stopes unite in one large stope. Up to this time practically all the broken ore has been drawn from the chutes, and also at a convenient point a raise has been run to the next level for ventilation. The stope is carried the entire width of the ore, but pillars are

THE GLORY HOLE AT THE MOTHER LODE MINE.

left at intervals to insure the safety of the roof. A manway into the stope is also provided, sometimes in the barren rock of the walls and sometimes in a pillar, or it may be carried up from one of the first short raises by cribbing. This preliminary work having been accomplished, the stope as a whole is carried up to the next level, only the excess of ore being drawn from the chutes, which excess is about 40 per cent of the whole. The ore is bulldozed as broken, to prevent the choking of the chutes; the miners standing on the broken ore are in reach of the roof and can guard against unsafe ground with temporary stulls. In the Mother Lode the work is arranged so that when all the ore above the first level is broken down it will be drawn from the stopes, after which, beginning at the furthest point from the shaft, the pillars and the roofs over the drifts will be robbed to the limits of safety and the level abandoned as worked out. This general procedure will be followed in succeeding levels as the workings grow deeper.

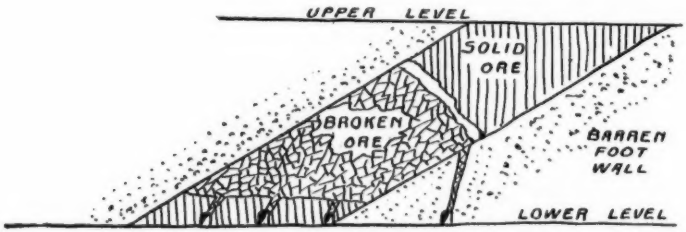


FIG. 2. SECTION OF A STOPE WHEN FOOT WALL IS SO FLAT THAT ORE WILL NOT RUN WELL.

In the Granby mines where the ore lies flatter than in the Mother Lode, it is usual to run three or more drifts under the ore to be stoped, and later on as the stope grows higher, a drift in the barren foot wall is run and raises made to reach the ore which will not run on the foot wall by itself. In this way shovelling the ore is mostly avoided, much reducing the costs of mining. Figure 2 illustrates the plan of extracting the ore along these lines.

Timbering Sill Floors.—(a) Wholly. In this method of extraction the ore is first removed from over the floor of the level to a height of about 12 feet. This floor is then heavily timbered and the ore broken down on the timbers until the level above is reached, only the "swell" of the ore being removed through chutes suitably placed as the work progresses. This method, while well adapted for small ore bodies, is scarcely to be recommended for big stopes, partly on account

of the expense involved, but mainly because the load is too heavy for safety unless the timbering be made tremendously solid and massive.

(b) Partially. Two variations of this method may be followed:

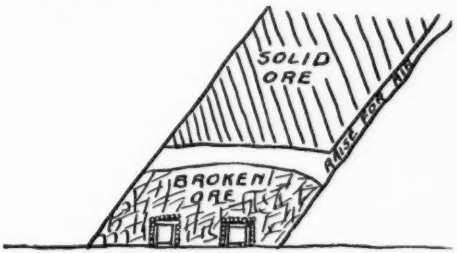


FIG. 3. SECTION OF A STOPE WITH TIMBERED WAYS.

1. The sill floor being wholly cut out as just described, timbered ways are built, these ways being solidly lagged over the tops and sides. The ore above is then broken down over and between the ways, the sill floors thus carrying the bulk of the load. Chutes are maintained at intervals along these timbered ways. Figure 3.

2. The second variation is followed to some extent in the Emma mine, where the ore stands vertically and is from 20 to 35 feet across. Here a single drift is run 10 to 12 feet wide along the ore. This drift is carried high and is roofed with very heavy stulls placed at intervals of 5 feet, and supported below by one or two posts to each stull. The stulls are covered with heavy pole lagging, and chutes provided at intervals of about 25 feet, the chutes being first on one side and then on the other of the drift. Stoping is then started, the stopes being widened in V shape until the walls are reached, when the work is carried up as usual. In this way the major part of the weight of broken ore is borne by the walls. Figure 4. In other sections of this mine the entire sill floor is timbered. As may be imagined, mining in this perpendicular deposit presents fewer obstacles than with those having considerable dip. The necessity for frequent support to the hanging wall through cross pillaring is here

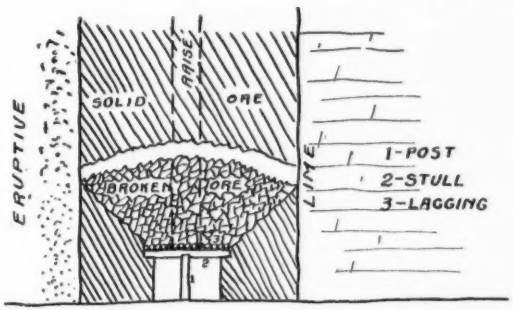
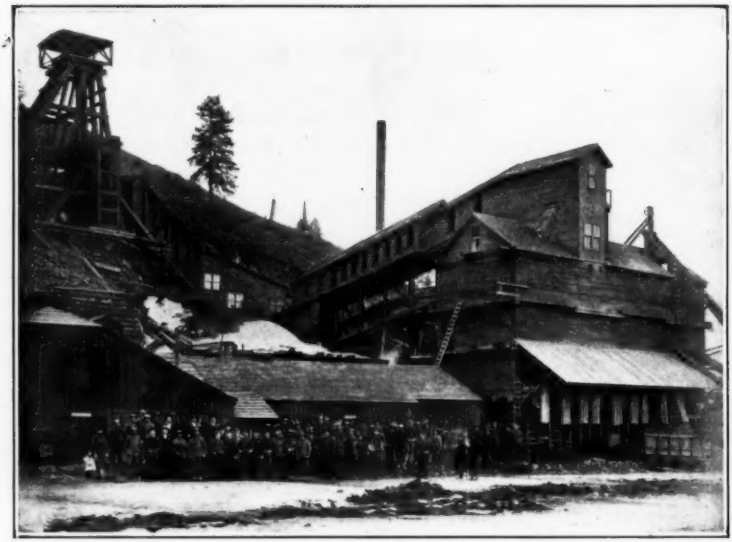


FIG. 4. SECTION OF STOPE IN EMMA MINE, WITH CENTRAL DRIFT COVERED WITH STULLS AND LAGGING.

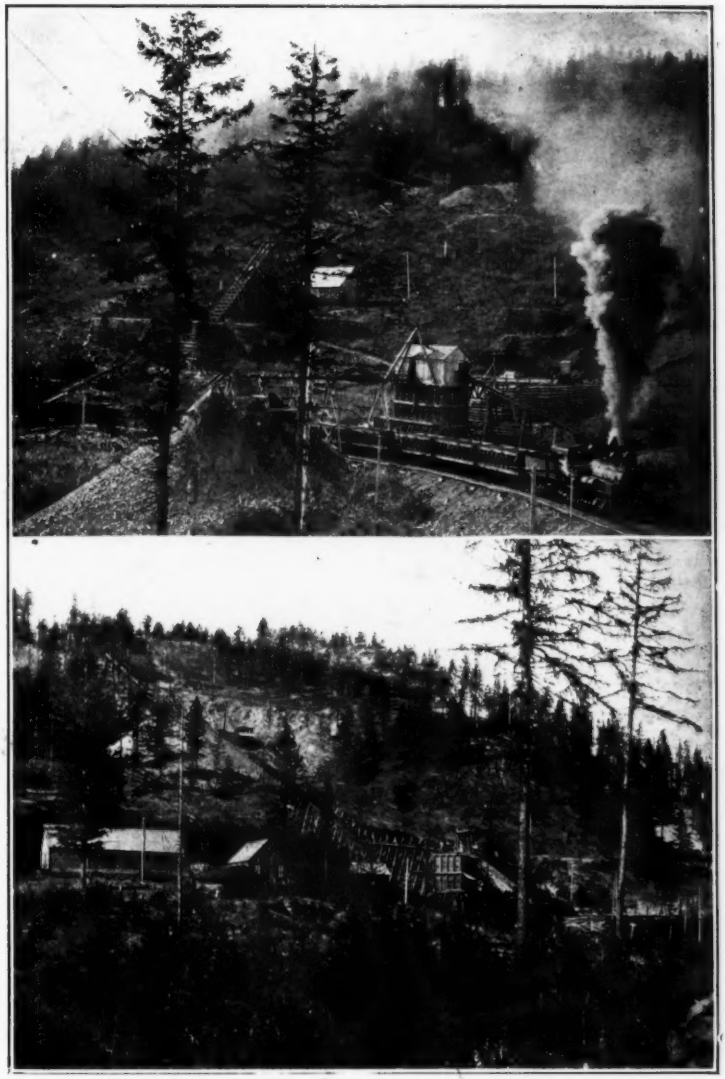
absent, and there is never any difficulty due to the ore refusing to run into the chutes.

Ore Handling.—In the Mother Lode mine all the ore, both from the glory holes and underground workings, comes to the main shaft where it is dumped into capacious pockets, smaller pockets being provided for waste. Several classes of cars are used. The most numerous are broad and low and of scoop pattern, capacity 2 to 2½ tons. The second class are side-dumping cars, capacity 3 to 3½ tons each. They are drawn by horses in trains of 4 to 5 cars.

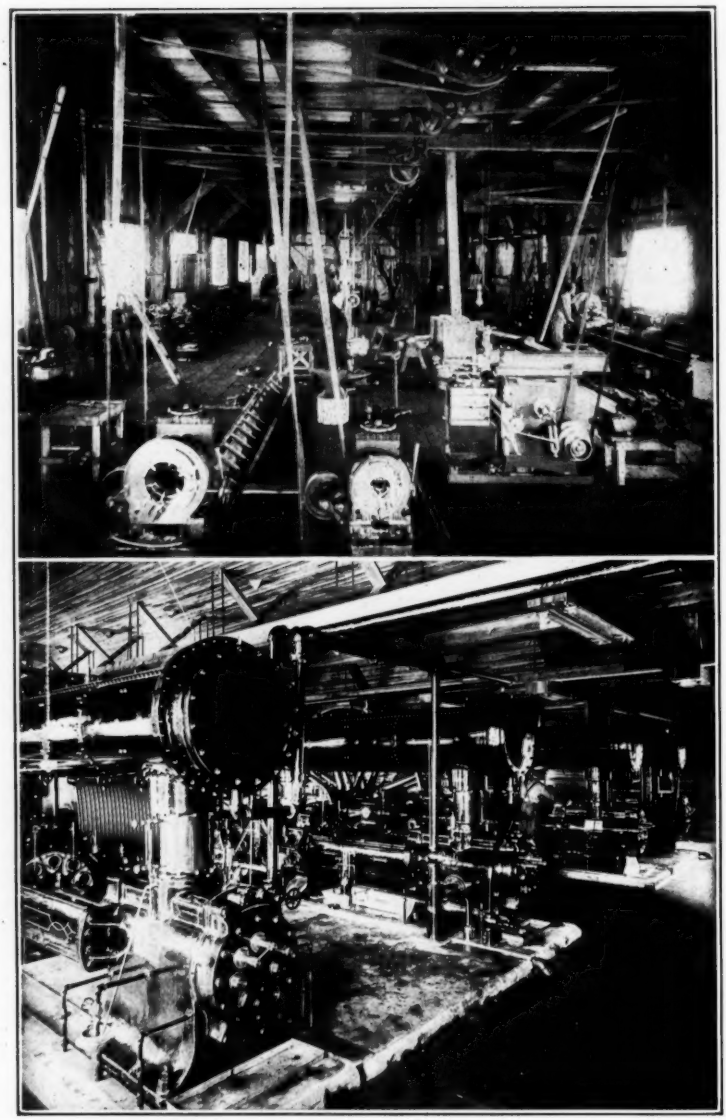


HEAD WORKS OF THE MOTHER LODE MINE.

The scoop cars on reaching the pockets are dumped by a tipple which after dumping throws the cars back on a side track. The side-dump cars are emptied as the train passes over the pockets, and are more rapidly handled than the scoops. These two classes of cars are built of ¼-inch steel plate with a double bottom consisting of two ¼-inch plates separated by 2 inches of planking. Besides these cars there are many 1-ton ordinary mine cars pushed by men where horses are not available. The ore is drawn from the pockets into 5-ton skips, and hoisted to a bin at the surface, whence it passes to either of a pair of electrically driven Blake crushers having jaw openings of 24 by 36 inches. The "fingers" to the chutes feeding the crushers are operated by compressed air, so that the crusher feeder has perfect control over his work. Lifts are also provided to turn around boulders

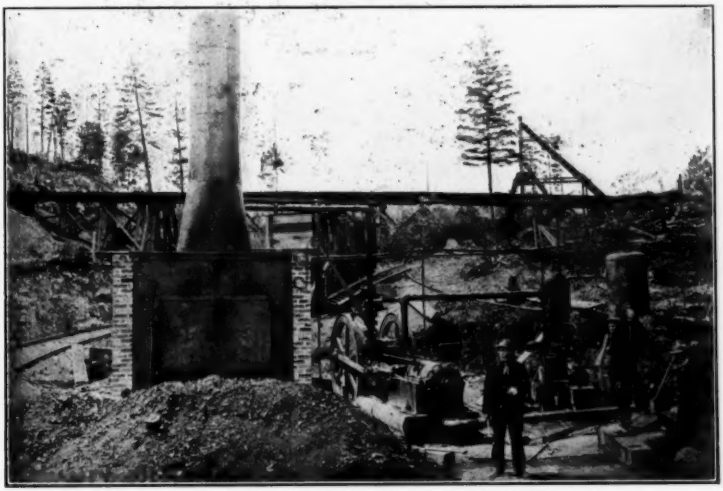


SNOWSHOE MINE, GRANBY COMPANY, PHOENIX.
RAWHIDE MINE, DOMINION COPPER COMPANY, PHOENIX.



MACHINE SHOP AND COMPRESSOR PLANT, GRANBY MINES, PHOENIX.
The compressor plant is for two 80-drill compressors.

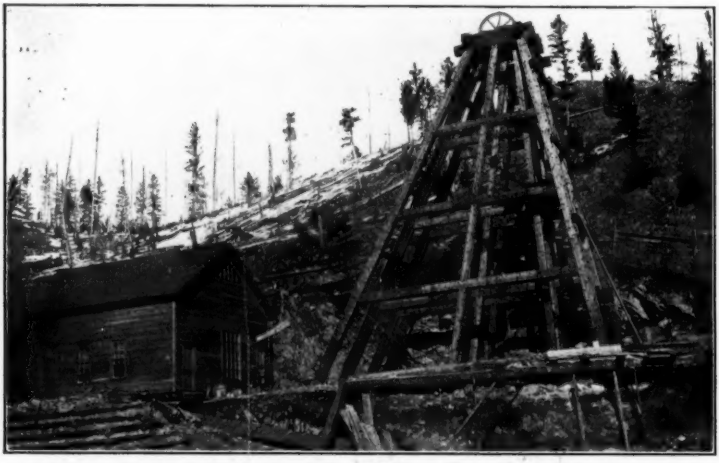
of ore which happen to fall in such a way that the jaws cannot take hold. From the crushers the ore falls onto a 36-inch conveyor belt which takes it to the railway bins 175 feet distant. The main shaft has four compartments each 4½ by 5 feet, two of which are for skips, one for ladder and pipe road, and the last for hoist cage. So far as possible the loading pockets communicate with the hoist by speaking tubes, enabling the skip loaders to direct the hoistman on occasion.



TEMPORARY COMPRESSOR PLANT, EMMA MINE.

In the Granby mines most of the haulage is done by electric motors and steam locomotives, which pull trains of 5 to 10 cars of capacity from 5 to 10 tons each. At two tunnel entrances to the mine on upper levels, bins are located in connection with which are enormous crushers with jaw openings of 30 by 42 inches, the crushed ore passing into railway bins. Connecting with the lower levels of the mine is a three-compartment incline shaft which will shortly be in commission. Here the ore is hoisted to a pair of bins whence it passes to a giant jaw crusher and thence over a long conveying belt to the railway bins. An ingenious device in the headframe at this shaft is a rotating bin near the top of the frame into which the ore or waste falls from the skips, and which by rotation delivers the contents of the skips into any one of three chutes as desired. Two of these chutes communicate with the bins above the crusher, while the third is for waste.

At the Dominion Copper Company's mines the ore is not crushed,



HEAD FRAME OF BOLTED PLANKING, MOTHER LODE MINE, IN CONSTRUCTION.

but is delivered directly to the railway bins, the crushing being all done at their smelter.

The air compressors, crushers, some hoists and most of the minor machinery are operated by electricity which has all but displaced steam power in the Boundary. Two plants supply this power. The smaller, operated by the Cascade Power Company, is located at Cascade Falls in the Kettle River about 25 miles from the centre of the mining district. The capacity of this plant is 2,000 to 3,000 horse power, depending somewhat on the season. The line voltage is 20,000. The larger power plant is that at Bonnington Falls in the Kootenay River, some 85 miles from the centre of the Boundary district. It is estimated that 60,000 horse power is available here at low water.

The general progress of mining in the Boundary (which ten years ago was practically a forest wilderness remote from any railway) can perhaps most impressively be illustrated by the following table of tonnages smelted at the three plants operated by the Granby, Dominion and British Columbia Copper Companies. For so young a district this is certainly a creditable showing.

Year.	Tons smelted.
1900	62,389
1901	348,439
1902	460,940
1903	697,404
1904	837,666
1905	982,877
1906	1,276,589
Total	4,666,304

THE PROPERTIES AND USE OF MINERAL LUBRICATING OILS.

By P. F. Walker.

Professor Walker's suggestive studies of lubricants fittingly round out a "Power and Production Number"; for the elimination of friction, in which lubrication plays a large part, is one of the very important elements in economy of production through the application of power.—THE EDITORS.

THE lubrication of the moving parts of high-grade machinery is coming to be of more and more importance as machines are being perfected, and as closely guarded systems of works management throw into prominence many hitherto unheeded sources of inefficiency and loss. Reduced friction losses effect savings in many different directions. They serve to increase the effective power from a given motor, or to make it possible to use smaller sizes, to reduce repair items incident to heated bearings, to prolong the life of the machine, and to reduce stresses in power-transmission machinery, thus permitting the use of lighter parts. Beyond a doubt the future will see much more attention given to the whole subject of lubrication than is now accorded it.

Probably no other questions connected with the operation of machinery are so poorly understood by engineers as a class as those involved in the selection of a lubricant for any special work. What has proven good in one place may not do so in another, or at least, it may not do as well as some other that may be found. A common failing of engineers is to conclude that an oil is the best which prevents a bearing from giving trouble by heating, has good lasting qualities, and costs little, without taking the trouble to find out if it is superior to other available brands in friction-reducing qualities. The failure to take this last matter into account is almost a natural outcome of conditions, since it is a tedious and costly process to test thoroughly, in actual service, the numerous oils which would be submitted in response to any general call for samples and bids. What is wanted is some simple test to be applied quickly and easily, which will give some positive information as to the real value of the lubricant.

The ordinary simple physical tests, consisting of the determination of congealing and flashing temperatures, loss by evaporation, and detection of acidity, are purely discriminative by nature. They serve to distinguish oils totally unfit for the conditions to be met, but a dozen samples might pass these tests with practically equal merit and no clue be given as to the real lubricating values. The determination of viscosity appears more promising in positive results, but even here attempts to draw definite conclusions are disappointing. Undue stress is often laid on viscosity values as indications of the value of lubricants, and many misconceptions exist as to the true significance of this property of oils. It is my purpose to point out in some measure, in this article, the real meaning of viscosity, as well as to refer to the significance of the flash point as a test of lubricants.

In passing it may be noted that many practical men attach too little importance to friction tests for lubricants on special machines. Unreliable as these tests may be in respect to furnishing absolute figures for frictional resistance in actual service, they do give comparative results which are positive indications of the values of different oils in reducing friction, which no other test can do. The vital conditions of pressure on the bearing and relative speeds of the surfaces in contact may be realized at will on the special machines, and because nearly all conditions are readily controlled on these machines, fairer tests will be secured from them as regards comparative lubricating qualities than will result from making brief trials on the actual machinery where conditions are liable to vary. Many machines for this purpose are on the market at reasonable prices. In selecting a machine it should be kept in mind that it is the oil that is to be tested, not the bearing or the actual friction coefficient to be expected in practice. This being the case, the machine should be constructed with special reference, first, to making the application of the lubricant to the bearing positive and absolutely perfect, and second, to the securing of good control of the temperature of the oil on the bearing. These two features are all-important. If the lubrication is not perfect in the machine there is no way of telling how imperfect it is, and the test becomes only a measurement of friction between partially oiled metal surfaces, instead of a test of the oil. Perfect lubrication is secured when the oil film is continuous, entirely supporting the journal, and to secure this condition the bearing should be flooded with oil, or, better still, be immersed, in full or in part, in an oil bath. The necessity for the perfect control of temperature arises from the fact that the viscosity

of the oil varies with the temperature, and no comparison of oils can be a true comparison unless corresponding conditions in this regard are realized. Since in bearings furnished with a limited supply of oil the film between the surfaces is bound to be of higher temperature than the metals of the bearing and journal, it is evident that temperature control can be best secured under the same conditions as are necessary for perfect lubrication; that is, by flooding the bearing, or immersing it. In this way the temperature of the film will be very nearly that of the oil flowing from the bearing. Temperature control is the most difficult of realization of all the necessary conditions in an oil-testing machine, and there is no absolutely perfect method possible; but the above is unquestionably the nearest approach to perfection.

In addition to the tests for the real lubricating properties, the machines are sometimes used for testing the durability of the oil, its capacity for conducting away the heat caused by friction, and the relative efficiencies of different methods of applying the lubricant. In my experience, however, these tests are unsatisfactory when made on the special machine, for the simple reason that they are influenced by the nature of the bearing, and what may be good for the special machine may not be good for the bearings on which the oil is to be used. If it is definitely understood that the special oil machine is to be used to measure the friction in continuous oil films surrounding the journal, and to determine the pressures under which an oil will form those films when conditions are perfect according to some standard method of application which is always possible of realization, then the misconceptions as to the significance of results, and suspicions as to their correctness and worth, will disappear. The machines may be used, of course, as they have been in the past, to establish laws of friction for lubricated surfaces under various speeds, pressures, temperatures, or viscosities; but in doing this perfect lubrication must be secured if the results are to be of practical value for all classes of service. There are no laws of friction for imperfectly lubricated surfaces, and it is useless to test oil under anything but standard conditions.

Mineral lubricating oils constitute the greatest portion, by far, of the fluid lubricants used in this country. Practically all of these are produced from crude petroleum by distillation and subsequent treatment to remove solid paraffine and other objectionable constituents.

The crude petroleum used in the United States as a source of lubricating oils has a paraffine base, and the products obtained by

distillation follow in a general approximate manner the order of the paraffine series, the chemical composition of which is expressed by the symbols C_nH_{2n+2}. With these, however, are associated, in varying amounts, unsaturated hydrocarbons of the ethylene and acetylene series, C_nH_{2n}, and C_nH_{2n-2}, respectively. The lighter distillates, forming the naphthas, gasoline, and kerosene, seem to follow closely the paraffine series, the latter product being composed largely of the nonane, C_9H_{20}, and the decane, $C_{10}H_{22}$. The heavier, later distillates are, however, extremely variable in their natures, showing evidences of the presence of large quantities of the unsaturated hydrocarbons. When the distillation of these heavier oils is carried on in a vacuum the fluctuation seems to be less erratic, but still there is more or less definite evidence of the presence of members of the lower series of hydrocarbons in some of the products. The effect of the vacuum is simply to lower the temperature at which the distallates pass over, thus diminishing the tendency of the oil to break up in chemical composition.

A peculiar fact brought out by the distillation processes, and one which is significant in relation to the lubricating-oil question, is that if the residue remaining after driving off the lighter oils (including most of the lubricating oils) be taken and redistilled destructively—that is, "cracked" as expressed in the ordinary vernacular—there may be recovered a complete series of distillates from the lightest gasoline down. This cracking process is a breaking down, chemically, of the oil, occasioned by too rapid heating in the still. It can be prevented only by the greatest care and skill. This shows that during the distillation for lubricating oil there may come over with the oil some of these lighter volatile products. Their presence lowers the flashing temperature which marks the limit of the usefulness of the lubricant, and increases loss by evaporation and tendency to gum.

The flash test reveals the presence of these volatile liquids, and is one of the most valuable of the physical tests. That some of the lighter substances are present in all our common mineral oils classed as engine oil or lighter, is shown by the fact that their flash points are always below 425 degrees F. The distillation for the production of kerosene is stopped at about 572 degrees F. at atmospheric pressure, and it is evident that if the heavier oils formed a regular series with the lighter ones they would yield no oil vapor to ignite below that temperature. The extent to which these volatile substances enter into the oil is indicated by the flashing temperature, and this test is thus really a test of the skill and care exercised by the manufacturers.

The low limit of temperature permissible for the flashing point of oil to be used on bearings is not a definitely fixed value. It must depend upon the conditions at the bearing. In places where heating is at all likely to occur in a noticeable degree, the safety of the bearing demands that the oil should retain its lubricating qualities at comparatively high temperatures. Since the temperature of the oil film is always much in excess of that which can be measured in the metal body of the bearings, the safe limit for flashing is higher than might at first be supposed. A figure sometimes mentioned is 300 degrees F. but this is too low for most classes of high-grade machinery.

The above discussion of low flashing points is based entirely on considerations of the power of an oil to lubricate at all. There is involved, however, a matter of greater moment than this, greater because the condition is more commonly realized. At temperatures only moderately high the loss of the oil by evaporation becomes considerable. If this evaporation is sufficiently rapid it will cause gumming and a gradual increase in the viscosity, which means an increasing friction loss, followed by greater heating and faster evaporation in a cumulative manner. This occasions a greater consumption of oil, and in continuous systems of lubrication where the oil is used over and over again, it is especially harmful. In engine-crank cases, for instance, the temperature may become comparatively high, and a volatile oil will gradually change in its friction-reducing qualities, to the detriment of the engine and ultimate waste of a large amount of oil. Actual evaporation tests of oils are tedious, and require accurate balances for weighing the samples, as well as good facilities for maintaining constant temperatures during long periods of time, but the flash test which is very easily made may be made to serve in an approximate manner for comparative purposes. In this connection the results of tests made by students under my direction are expressive. The tests were of thirty-hours duration, the oil being in shallow trays set in a bath of water for the lower temperatures and of oil for the higher. Each sample of oil weighed about 80 grammes at the beginning of the test.

RESULTS OF EVAPORATION TESTS.

No. of oil sample.	Density at 60° F.	Flash-Point.		Evaporation loss in 30 hrs., %.		
		Closed cup.	Open cup.	150°	200°	250°
1	.902	354°	416°	0.4	0.4	1.0
2	.867	340°	372°	0.4	0.6	2.2
3	.872	272°	290°	3.2	12.4	24.2

Figure 1 shows graphically the variation in evaporation loss with the flashing temperatures of the oils. The results from the closed-

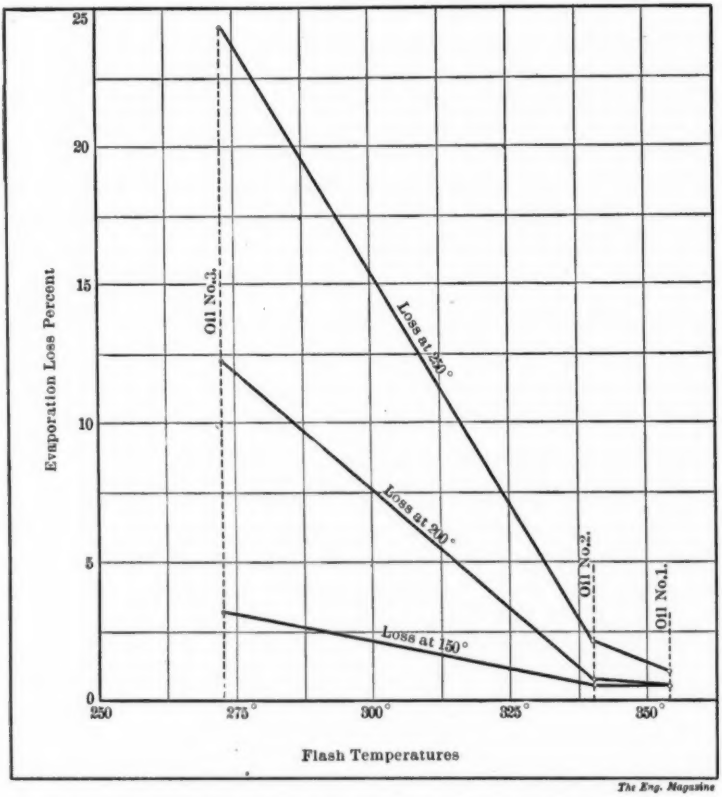


FIG. I. GRAPHIC RECORD OF EVAPORATION LOSS OF DIFFERENT OILS.

cup method of determining the flash point are here used, but the open-cup results would show the same degree of variation. The points for the different oils are connected by straight lines, since three points are hardly sufficient to determine the nature of a curve in an unexplored field like this, but the indications are that the three points for each temperature at which the loss was determined lie on a curve hyperbolic in form, and approaching parallelism with the horizontal axis at the right. The results which have been found for a fourth oil of higher flash temperature than Number 1 confirm this view. It is not probable that the loss would become zero, even for oils of very high flash point, when the temperature is held at 200 degrees or over, because of the chemical unstability of mineral oils. As it stands, how-

ever, the diagram shows plainly the marked increase in evaporation losses with oils of low flash points, at temperatures not uncommon in ordinary bearings. It should be remarked that oil Number 3, with the low flash point and high evaporation loss, was a paraffine oil, so-called, which had not been treated by chilling or otherwise to remove solid paraffine or other natural constituents. The point is well established by these tests, however, that evaporation losses are greater for low flash points, although there are insufficient data to establish numerical relationships.

Oils, or other liquids, act as lubricants in virtue of their ability to form continuous films over the surfaces to be lubricated. In some cases, as in engine-cylinder lubrication, the film must be formed through the tendency of the liquid to spread over a solid. In other cases the oil is drawn between the surfaces by the motion of the parts, and it becomes more a question of the oil-film's ability to withstand the pressure applied to it without being forced out or without allowing the surfaces to come into contact. It follows, then, that the lubricating properties of oil are more properly considered as properties of films than of masses of oil of considerable thickness. The investigation of the properties of thin films of oil has received but little attention, hence the present uncertain condition of our knowledge of the absolute friction-reducing properties of oils.

The properties of the film which tend to resist its ejection from between two surfaces where it has been carried, are viscosity and the tensile strength of the film. Viscosity is the measure of the force required to move one layer of a liquid over another layer of the same liquid, whether those layers are infinitely thin or of appreciable thickness. In other words, it is the shearing strength of the liquid, taken along the plane parallel to the direction of motion. Evidently, then, an oil of considerable viscosity offers a greater resistance to any force or pressure tending to expel it from between two surfaces than does one which has a lower viscosity, and consequently an oil of high viscosity will permit the exertion of greater unit pressures on a bearing without being driven out.

The tensile strength of the film resists the tendency of irregularities in the surfaces to rupture it, and likewise, if the film should be thus broken or greatly thinned, causes the oil to reform the film after the irregularity has passed. Undoubtedly this film strength bears a definite relation to the strength of the film which forms on the free surface of a liquid, or on the surface separating liquids of different densities. This latter property of liquids causes it to rise into small

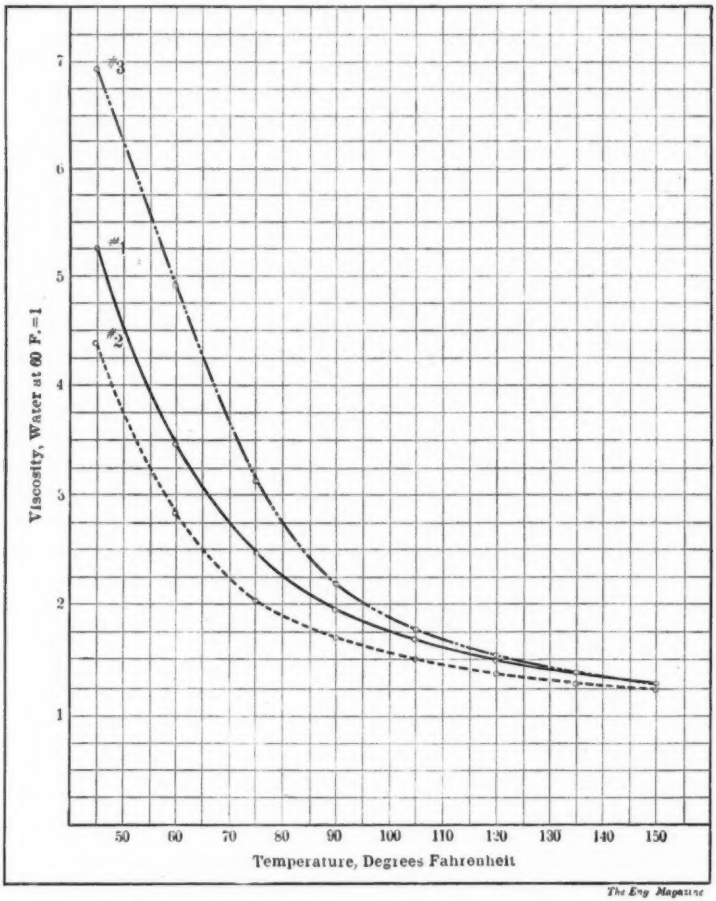


FIG. 2. GRAPHIC RECORD OF VISCOSITY TESTS ON SEVERAL OILS.

tubes and around the edge of a containing vessel, and is often called capillarity. By the physicist the strength of the film thus formed is called "superficial tension," or merely "surface tension." Lord Rayleigh, the eminent English scientist, has done a great amount of work in this direction, and he has shown that when several liquids of different surface-tension values are in contact, equilibrium exists when they are arranged in the order of their surface-tension values, the liquid with the lesser value spreading over the one with the higher

value. Metals, having high surface tension, will thus be covered by most fluids, which have smaller values. Mercury, however, which has a very high surface tension, does not spread over the solid metals.

This tendency of liquids to spread over metals in films more or less thick, which tendency is measured by the superficial tension, is a valuable one in a lubricant, although it has been shown that the friction-reducing qualities are not in direct proportion to the surface-tension values. In the lubrication of a steam-engine cylinder it is an all important property, and hence cylinder oils should be high in surface tension, especially since they must resist the tendency of water of condensation, with its high surface tension, to displace the oil film in order to satisfy the conditions of equilibrium discovered by Lord Rayleigh. Fortunately water does not form stable films.

One more characteristic of oil films between surfaces moving relatively to each other should be noted.

In continuous films between surfaces, one of which is at rest and the other in motion, either actually or relatively, the shearing force set up is proportional to what is called the rate of distortion. This rate of distortion is simply the ratio of the distance moved by one thin layer over another in unit time, to the thickness of the layer. Therefore the greater the number of thin layers, or the thicker the film, the less will be the shearing force, and hence the less resistance, or friction, in the bearing. This may be seen by placing a pack of cards on a table and with the hand on the uppermost one, moving the whole to one side. For a given movement of the uppermost card and a given thickness of the cards, the more cards the less each one moves on its next neighbor. Hence, in the case of fluid friction, the less will be the resistance to motion, and it follows that oils which form thick films are the best lubricants, other things being equal.

To summarize, for an oil to be a good lubricant for a given service it should have the following characteristics:—

The least viscosity consistent with the pressure to be sustained.

The ability to form thick films.

Readiness in forming films over metal surfaces, and power to resist rupture.

A flashing temperature sufficiently high to avoid loss by evaporation, varying consistency, gumming, etc.

The characteristic of most importance in a given case depends upon the conditions of pressure, and methods followed in applying the lubricant.

Surface tensions of lubricating oils are seldom determined, but

may be found by drawing a small, clean glass tube from the oil and measuring the force required to separate it from the oil by attaching it to one arm of a delicate balance.

Viscosity is usually measured by the time required for a given amount of the oil to flow through a standard orifice, referred to some standard fluid. Figure 2 gives the results of a series of tests carried out under my direction by a different group of students at a different school from that in which were made the evaporation tests already discussed. In this work, however, oils Number 3 and Number 2 are from the same refiners and of the same grades as are Number 1 and Number 2 respectively, in the evaporation tests. Oil Number 1 in the present series is lard oil.

It is seen in Figure 2 that as the temperature rises the viscosity values approach each other, becoming nearly coincident at 150 degrees F. Extensions to these curves made later, at temperatures up to 350 degrees, bring the values still closer.

Figure 3 shows the actual coefficients of friction for the same oils, under varying pressures. These values were taken on a machine designed by Professor Carpenter of Cornell University, in which the bearing rests on top of a journal about 4 inches in diameter. The width of the bearing was 2 inches, thus enclosing about one-sixth of the circumference of the journal. The bearing was of brass, and the journal steel. This form of bearing permits high unit pressures with little danger of heating.

This diagram presents some interesting features. Up to about 200 pounds per square inch the oil of least viscosity shows the smallest coefficient, as is to be expected. Above this pressure the oils change relative positions, confining our attention to the two mineral oils, Numbers 2 and 3. The reason for this is not entirely clear. The first thought might lead one to the opinion that the oil of less viscosity had reached its limit of pressure-sustaining qualities, and that for the higher pressures it was being forced from the bearing and lubrication becoming less perfect. To treat the question fully, however, the temperature in the bearing must be considered. Temperatures were taken by a thermometer placed in a cavity in the side of the bearing, but not in contact with oil in the bearing proper. Hence the true temperature of the oil film must have been considerably higher than those recorded. At pressures of 200 and 250 pounds per square inch the temperatures at the ends of the runs were about 85 degrees and 100 degrees respectively, as recorded, which means that the probable temperatures of the oil films were considerably higher. This would

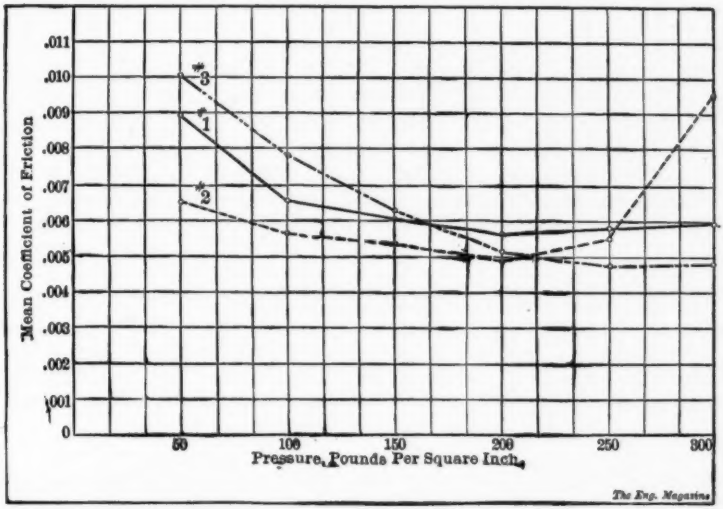


FIG. 3. FRICTION COEFFICIENTS OF OILS WHOSE VISCOSITY IS EXHIBITED IN FIGURE 2.

bring the oils to a position on the viscosity curve, Figure 2, where the viscosities were approaching each other. For the runs at 300-pounds pressure the temperatures were such that the viscosities would be practically equal. It therefore seems doubtful if differences in viscosity were sufficient to account for the marked differences in the friction. Without doubt the lubrication became less perfect with oil Number 2 at the high pressure, but in my opinion this was due more to differences in the film-forming powers of the oils at the high temperatures than to differences in viscosities.

The above serves to illustrate in a striking manner the many difficulties and pitfalls in the way of the oil tester, and also to drive home the conviction that there is still much to learn in the lubrication field. So far as I am aware no work at all has been done with films, in the manner that seems necessary to explain many of the phenomena observed. It is largely my purpose to point out in the present article the need of more work in all phases of the oil question, and especially in the direction of the film-forming properties. An interesting field of work awaits the man who, with sufficient time at his disposal, takes up these phases of the question.

EDITORIAL COMMENT

THE movement for reducing the risk to life and property in hazardous occupations should receive a strong impetus through the action just taken by the United States Geological Survey. An experiment station is to be established, probably in the Pittsburg district, for thorough practical tests of all explosives used in coal mining, the candle power and relative safety of miners' lamps, and the efficiency and life-sustaining power of rescue apparatus. Miners will be given instructions and demonstrations in the rescue of their fellows. The knowledge secured through experimenting on a really large scale will be disseminated with the object of reducing the number of mine disasters arising from gas and coal-dust explosions.

The explosives gallery will consist of a boiler-plate cylinder, 100 feet long and 6 feet in diameter, with safety valves on hinges along the top to allow escape of the gases of explosion, and plate-glass covered port holes on the sides through which an explosion may be seen from the observation gallery 60 feet away. Suitable gauges will record the actual pressures developed; the temperatures of explosive decomposition will be measured, the rate of detonation determined by a rotary recording drum, the length of the flame photographed. From the data secured will be determined the maximum quantity of each explosive that can be used safely, and the results will be published under the head of "Permissible Explosives."

Under Mr. J. A. Holmes, chief of the technologic branch of the Survey, the work will be in charge of Dr. Charles E. Munroe, Mr. Clarence Hall, explosives expert, who has just returned from the study of similar work abroad, and Mr. W. O. Snelling. It promises much for greater safety in coal mining.

* * *

THE disturbing rumor of bad foundations for the Gatun locks which has appeared at several critical periods is finally silenced by the report presented by Messrs. Noble, Stearns and Freeman, on their return from their recent examination of the ground. The assurance from such authorities that (to quote from their brief and direct report) "all of the locks, of the dimensions now proposed, will rest upon rock of such character that it will furnish a safe and stable foundation" is completely satisfying.

They add a detailed statement of the examination and the results. At Gatun, five test pits about 6 feet square had been sunk to or below the level of the lock walls. The deepest was 87.4 feet in depth. All entered rock a few feet below the surface of the ground and continued in it to the bottom. The three consulting engineers personally went down into each pit, and they found everywhere, with one exception, a fine-grained, bluish-gray rock which Mr. Ernest Howe calls an "argillaceous sandstone." The exception was a conglomerate found in the lower 8 feet of test pit No. 1. The quantity of water percolating into the pits was of no practical importance.

At the site of the Gatun regulating works the same blue-gray argillaceous sandstone was found; under the Pedro Miguel locks the same rock is interrupted by a trap dike which will furnish support the greater part of the length of the lock walls, while the Sosa locks will rest wholly upon the hard trap. Thus Mr. Stevens' report to the Senate Committee is most amply confirmed.

REVIEW OF THE ENGINEERING PRESS.
"THE WORLD IS ITS FIELD"

THE EFFECTS OF THE SAN FRANCISCO EARTHQUAKE AND FIRE ON BUILDINGS.

A SUMMARY OF THE CONCLUSIONS REACHED AFTER EXTENSIVE INVESTIGATIONS BY A COMMITTEE OF THE AMERICAN SOCIETY OF CIVIL ENGINEERS.

Proceedings of the American Society of Civil Engineers.

RECOGNIZING the value of the professional lessons which were to be learned by a careful study of the effects of the San Francisco earthquake and fire on all classes of engineering structures, the American Society of Civil Engineers, shortly after the disaster, instituted an investigation of the subject through a committee of the local Association of Members. The report of this committee was presented at a recent meeting of the Society and presents a great deal of authoritative information of the highest importance. The report is divided into sections dealing with geology, buildings, water works, sewers, lighting and street railway transportation, railway structures, and highway structures. The following extracts are taken from the general summary of the section on buildings which is the largest and most important feature of the report.

"The effect of the earth motion is to set a building in motion. The structure is thus subjected to all the stresses occurring in a truss sustaining a live load. The amounts of the stresses are unknown, and cannot be predicted, as the intensity of the shock is unknown. Obviously, the shock may range from a tremor to that of a violence that would wreck any building. Again, should the earth-slip take place beneath a building, it would be wrecked. Sufficient evidence is at hand to warrant the statement that a building designed with a proper system of bracing to withstand wind at a pressure of 30 lb. per square foot will resist safely the stresses caused by a shock of an intensity equal to that of the recent earthquake in California.

"The prime requisite of the structure is elasticity. This must be understood as the ability of a structure to return to its original form after distortion. This elasticity allows the building to absorb the motion of the earth, where a more rigid structure would be ruptured.

"To this requirement, the building with a timber or steel frame answers very well. The reinforced concrete structure does so also, with the exceptions noted below. The building with stone, brick or block construction, having horizontal mortar joints, does not answer the requirement at all. It may be stated, as one of the most obvious lessons of the earthquake, that brick walls, or walls of brick faced with stone, when without an interior frame of steel, are hopelessly inadequate. As a method of building in earthquake countries, such types are completely discredited.

"To resist the shearing effect of the horizontal earth motion, vertical members are necessary. The shear is transformed into diagonal forces, which appear as stresses in diagonal and horizontal members. There was probably no better illustrated lesson

of the existence of diagonal stresses than that offered by the innumerable instances of the cracking of brick and stone work along diagonal lines. In relation to this, it may be stated that a brick spandrel wall adds little, if any, to the bracing of a steel frame. Many such walls were cracked badly, and moved on the supporting girder. No reliance should be placed upon them, as they are open to all the objections stated in connection with brick walls in general. The well designed steel frame offers the best solution of the question of an earthquake-proof building, as all the stresses can be cared for. The well-designed timber-framed house is also adequate. A reinforced concrete building offers a solution, but is open to the following objections:

"Architectural reasons demand that diagonal bracing shall not be used except on rare occasions. This is overcome by the use of gusset plate knee braces and portal braces in the steel frame. Such design induces severe bending moments in the columns and girders; and in the girders the moment may be of the opposite character to that of the floor loads, thus producing tension in the upper flange of the girder. As at present designed, no reinforcement is used at that point, and hence such a girder would be defective. Again, it will be found upon analysis that relatively great stresses occur at points where the girders join the columns, especially in the lower floors of tall buildings. Here, again, the reinforced concrete construction, as now designed, is weak. These remarks are offered more in connection with high buildings. They can be overcome by the designer in reinforced concrete. All the evidence in the recent shock favors reinforced concrete, but the writers are of the opinion that the steel frame offers the best solution of the problem.

"Foundations did not suffer at all, no instances of any damage having come to hand. Some discussion has taken place as to the advisability of making a monolithic mass under buildings. Several of these have been constructed, such as the Claus Spreckels, Mutual Savings Bank and Bullock and Jones buildings. They are all of relatively small base. It is commercially impossible to construct a monolithic base under a building, say, 12 stories high, and having a base of 150 ft. Buildings of that size and larger, with isolated pier foundations, suffered no more than others. The evidence is that foundations well built, along accepted lines, are adequate. It might be claimed that, if such had been used in large structures, the damage would have been less. The evidence does not point that way, for even if the monolithic base were sufficiently strong to resist the vertical earth motion, the horizontal motion would still vibrate the structure.

"Finally, it may be asked whether difference in workmanship was not responsible for many of the results. While it is true that good workmanship gave better results than ordinary, it is still the opinion of the writers that it was mainly a question of design. Agnews' Asylum was of brick, laid in a fair grade of lime mortar. Ten miles away, on similar ground, St. Patrick's Academy, of similar design, was of brick laid in lime and Portland cement, and there was better work than at Agnews'. The damage at the latter place was less than at the former, but, as far as use was concerned, both places were demolished. The tower at St. Patrick's Academy was of brick, laid entirely in Portland cement mortar, and the work was so well done that the brickwork invariably broke through the bricks and not at the joints; yet the tower was completely destroyed; in fact, it was the worst wrecked of all the buildings there.

"The writers simply reiterate the statement that, speaking generally, buildings of brick walls and wooden interiors cannot be built which will not be wrecked in a severe shock, it being a fault of design and not of materials or workmanship.

"Any deductions from the fire must be those based upon a general conflagration, and not those of an isolated fire. In view of the complete destruction of all materials it becomes a question as to what should be done to make a building fireproof.

"San Francisco was built probably in about the same way as other cities. It is an error to say that it was a wooden frame city, as the business district was generally composed of buildings with brick walls. In among these had been constructed the so-called fireproof structures, ex-

posed on all sides to danger by the burning of the inflammable structures around them.

"The only statement that can be offered is that the best insurance for buildings would be the isolation of a district containing nothing but fireproof structures. A general conflagration would then be impossible. Manifestly, this is impossible in San Francisco, where business must be resumed with the least cost. In many cities it would be good insurance for men owning large buildings to combine to buy out old and inflammable structures, either demolishing or rebuilding them. Otherwise, there remains the danger of general conflagrations, such as those at Baltimore and San Francisco, in which fireproof buildings will be injured from 30 to 60 per cent.

"Turning to the individual building, the question of the exterior walls must be settled. There does not seem to be much choice of material. Architectural considerations demand the use of brick, terra cotta, or stone. With a steel frame supporting the walls at each story, any local fire will destroy the nearby facing, but it may be removed without damage to adjoining parts. This cannot be done when walls are self-supporting and the facing acts as a part of the wall. This risk of damage must always be carried, gradually becoming less as inflammable buildings are eliminated.

"There is no doubt that the steel frame is adequate for all its purposes, but it must be protected. This brings up the general subject of fireproofing, in which is involved the construction of floors and partitions and ceiling and column protection. Where any reasonable protection was given the steel frames of buildings in San Francisco the steel was uninjured, and hence the writers feel warranted in stating that it is possible to protect such a frame so that it will pass uninjured through a fire that consumes all parts that can burn.

"It was stated previously that all materials were destroyed by fire; it follows, from this, that the destruction of fireproofing must be expected and that it will have to be restored after a fire. It becomes a question, then, of selecting the material that will stand up best, for the fireproofing must retain its form, even if destroyed.

"In the writers' judgment, the column should be of a closed form, such as channels and plates. This is preferable to latticed columns. For columns, the fireproofing that will stand up best is red brick set in Portland cement mortar. Equal to this is a casing of solid concrete at least 4 in. thick, with a mesh of reinforcing metal. Examples were found in the St. Francis Hotel and Shreve Building, where the concrete was uninjured. In the Fuller Building, which was used as a paint and oil warehouse, the floors were of wood, and the columns were covered with from 4 to 5 in. of concrete. This protection held in place when the columns fell. It was completely destroyed, but the column shafts were protected. Next in order, and of equal merit as far as examples show, is the double wire lath and plaster protection, which, in the Wells Fargo Building, afforded complete protection. In many buildings, columns were protected by one layer of lath and plaster, directly applied, and then the entire column, with pipes, etc., was enclosed by the regular partition. This afforded complete protection, and the Merchants' Exchange and Kohl buildings are examples. The examples of the Fairmount and Alexander hotels are not included, as obvious defects in design and execution warrant the statement that the columns in these buildings were practically unprotected. The same remark applies to the melted cast iron columns of the Sloan Building.

"The remaining examples of column failures must be laid to the failure of terra cotta tile. The work in the Mills, Crocker and Aronson buildings was well done, but in all, and in the latter case especially, it failed utterly to afford complete protection. As the failure of one column section means the practical destruction of all floors supported by that column, the results are serious. In justice to the terra cotta tile, it must be said that in the St. Francis Hotel, the Union Trust and some other buildings it stood up well enough to protect the columns. The writers believe, however, that it is the least valuable of all materials commonly used for fireproofing.

"For floor construction, some form of reinforced concrete is far preferable to tile. In all cases the record of concrete is better than that of tile. Connected with this

is the protection of the lower flanges of beams and girders. The fire shows that a cover of lath and plaster directly upon the flange, protected again by the suspended ceiling, is the best. The layer of plaster alone on the flange will not protect. Neither will the thin piece of terra cotta strapped on. It may be stated here that one of the most obvious lessons taught by this fire is the protection to concrete floors and floor beams by the suspended ceiling of lath and plaster. In all cases where used it afforded complete protection. Where not used, concrete was destroyed and beams were distorted.

"The subject of partitions is bound up with that of column protection. Terra cotta tiles are inferior to lath and plaster, although both were destroyed. A partition may be destroyed, but, if it stands, it impedes the spread of fire, and, in this light, the lath and plaster type is superior to tile. It should be possible to construct better partitions, but as yet no better ones have been offered.

"A logical deduction from the statement that all materials were destroyed is the conclusion that all structural parts of a building, of whatever material constructed, must be protected by another material which will be a more or less complete loss in a fire. This applies to a steel frame, to floors of any type, and to roofs. It is impossible to protect some parts, such as fronts, partitions and other parts directly exposed. The floors and frame constitute the structural parts, failure of which means destruction of the building. All such should be fireproofed. This remark applies with equal force to buildings with reinforced concrete columns, girders, beams and floors. As integral structural parts, they should be fireproofed as well as similar members of a steel frame structure, for concrete is destroyed by fire nearly as quickly as steel.

"No further comment is offered, except the following: Buildings with wooden floors will be completely destroyed in a fire. Such parts as metal trim, wire glass and steel shutters were not used to sufficient extent to warrant any definite conclusions, except to say that what showing there was was favorable. Whether this expense is warranted was not determined. Bad work and indifferent construction will cause any material to fail. Good work will enable a poor material to stand up. Fireproofing should be continuous, and at no place should it be cut into for the passage of pipes, etc. The subject of pipes should be treated as it deserves, and proper ducts and shafts should be provided, instead of allowing them to be placed anywhere where they will give the least trouble in installation."

THE VENTILATION OF SUBWAYS.

A DISCUSSION OF THE EFFICIENCIES OF THE METHODS EMPLOYED FOR VENTILATING SUBWAY TUNNELS.

M. C. Birault—Société des Ingénieurs Civils de France.

ALTHOUGH the problem of securing adequate ventilation is one of the most perplexing and important in the operation of tube railways, the question has nowhere been given the attention which it deserves. Underground railways, as a means of solving the rapid-transit problem in large cities, have increased with great rapidity in both number and extent, but without commensurate improvement and development in the details of operation. With the exception of a very few cases, the ventilation in such subways is defective and the consequent discomfort of passengers leads to endless dissatisfaction and complaint. The question has been thoroughly discussed in a paper by M. C. Birault, recently read before the *Société des Ingénieurs Civils de France.* M. Birault also discusses the ventilation of railway tunnels, but the following abstract refers only to the section of the paper which deals with city subways.

Ventilation of subways must be arranged to deal with two sources of discomfort, the vitiation of the air and its increased temperature. Vitiation is caused by the carbonic acid and moisture given off by the great number of passengers carried daily in the tubes. Organic products of a poi-

sonous character are also found, the precise nature of which is still not thoroughly understood. The increase in temperature in subways is also due to the large numbers of passengers using them; and the friction produced by starting running and stopping the trains generates a considerable amount of heat and is another of the principal causes of the higher temperature. Particles of metallic and siliceous dust are also produced by the friction of the trains. These particles remain in the air, are violently stirred up by the passing trains, and are very liable to cause pulmonary diseases.

Experience has shown that natural ventilation is not usually sufficient to change the air of tubes which carry much traffic. It was formerly supposed that the movements of the air produced by the running trains would have the effect of drawing in fresh supplies of air from stations or other special openings. But the trains do not displace the air as they would if they acted like pistons. In double-track railways the air remains practically stagnant. The air driven forward by the head of the train immediately passes to the rear, and the current of air is in the opposite direction to that of the train. Whirling eddies of air are set up, which in all cases reduce the speed of the air current. These eddies are also to be found in single-track tubes, where, however, the general displacement of the air is in the same direction as that of the train.

M. Birault devotes a great deal of space to descriptions of the means used to ventilate the subways of European and American cities, and from the extensive and valuable data which he has gathered he is able to draw some general conclusions as to the efficiencies of the various methods of tunnel ventilation.

Moderate ventilation considerably reduces the proportion of carbonic acid and moisture in the air of subways. In some of the cities in France, where operation of trains is suspended for several hours during the night, it has been found that simply opening the doors of the stations during these hours creates sufficient draft to carry off a great part of the products of respiration. Such ventilation, however, while offering a convenient means of reducing the carbonic acid content of tunnel air, is not sufficient to carry off the bacteria and organic matter of a poisonous character which give rise to the bad odor so common in subways which are used by large numbers of passengers, nor does it materially lower the temperature. It is necessary, therefore, to arrange for a very active ventilation if all the objectionable features are to be removed, and since natural ventilation is generally insufficient, it is necessary in most cases to resort to mechanical means.

Subways may be ventilated by means of fans in one of two ways, either by installing powerful fans long distances apart, or by means of small units placed close together. Ventilation in long sections is very successful when applied, as in the case of the Central London, only during the hours of non-operation of trains. But the effect of the eddying movements set up in the air by the passage of trains running at high speeds and on close headway, is to seriously impair the efficiency of the ventilation, even in the case of double-tracked tunnels. Further, unless double doors are placed at all intermediate stations, the entrance and exit of passengers is attended by great discomfort, and additional eddy currents are set up in the air owing to the constant opening and closing of means of communication with the outside. It is advisable, therefore, to effect the ventilation of tunnels in short sections by means of small installations. In any case, the impure air should not be allowed to escape by means of the station entrances, but should be carried off through special openings and discharged at a considerable height above the street level.

It seems to be generally recognized that ventilation can be effected better by drawing out the impure air than by forcing in the pure. In most of the tunnels where mechanical ventilation is employed, exhaust rather than plenum fans are used. By this arrangement passengers enter the stations with the current of pure air instead of against the vitiated stream. In Boston, the impure air is drawn out by fans placed midway between each pair of stations, an arrangement which has given great satisfaction.

M. Birault considers it of great impor-

tance from the point of view of hygiene that the ballast of tunnels should be covered with asphalt or similar flooring. The ballast collects all sorts of impurities and being easily cast into the air as dust, is a constant menace to the health of the passengers. Furthermore, the presence of uncovered ballast prevents the easy cleaning of the tunnel which should be thoroughly washed out from time to time.

THE MARINE STEAM TURBINE.

THE PRESENT STATUS OF THE STEAM TURBINE FOR THE PROPULSION OF LARGE LOW-SPEED VESSELS.

Engineering.

IT seems to be generally considered that the marine steam turbine has failed to fulfil the claims made for it by its original advocates. Its application to vessels of large size, designed to run at high speeds, has proved a success, but numerous difficulties seem to stand in the way of its promised universal application to all classes of ships. The following extracts are taken from a recent editorial in *Engineering*, in which the general feeling of disappointment is expressed in concrete form for the first time.

"The various successful trials of turbine steamships made during the past twelve months have generally been hailed as further triumphs for the marine steam-turbine. In many respects this conclusion is entirely justified; but, at the same time, it must be confessed that the trials left matters pretty much where they were before. The pioneer turbine boat, the Turbinia, established once for all that the turbine could meet and beat the reciprocating engine when applied to the propulsion of high-speed craft. Such vessels must, however, always form but a small, if important, minority of the total tonnage of the world, and we seem no nearer than we were eight years ago to the solution of the problem of adapting the turbine to the propulsion of even the larger size of tramp steamship. From the outset it has been recognised that the difficulty has lain with the propeller. Even in the case of high-speed boats the turbine has had to be run much below its most economical speed, and this has been the case although its dimensions have been enormously increased as compared with those of equal output applied to the driving of electric generators. The maximum peripheral speed of the buckets in marine work is commonly much less than half that of a turbine employed for electric lighting; and if the same general design were followed in the two cases, the turbine should be at least four times as long if equal economy were to be maintained. Moreover, in order to get this relatively low peripheral speed at a moderate number of revolutions per minute, the diameter of the turbine has to be increased, which again involves a marked augmentation in the weight of the machinery per horse power developed. The designers have gone in this direction nearly as far as they dared, and as a consequence the total weight of the turbine machinery fitted to steamships seldom shows an advantage of more than 5 per cent. as compared with reciprocating engines. In electric-light practice the turbine unit often weighs only one-fifth to one-sixth as much as the corresponding reciprocating unit. In spite of the relatively high weight of the marine turbine, it is nevertheless, as stated, run in general much below its most economical speed; and here undoubtedly is to be found one reason for the disappointing results which have in some cases been realized in service. In no instance, we believe, has the turbine engine failed to beat, both in speed and economy, a sister reciprocating boat on the measured mile. In service, however, the latter has, in more than one instance, proved the less expensive in the matter of fuel. As the difficulty with the turbine is to get its speed down, designers have naturally selected as their speed for calculation that aimed at on the trial trip. With turbines in which the speed is maintained constant at all loads, as in those employed for electric lighting, the hydraulic losses below the governor-valve remain a nearly constant proportion of the useful work done, so that throttling

the steam to diminish the output some 20 per cent. or so means no serious reduction in the economy. If, however, at the same time that the steam is throttled, the speed of the turbine is reduced, additional losses, arising from hydraulic shock, are added to those due to throttling, and the steam used per indicated horse power per hour may very rapidly augment, particularly if, as is invariably the case in marine practice, the turbine is much underspeeded, even at full power. It would appear, therefore, that specifications for turbine-boats should lay much more stress on the economy to be attained during service conditions than on the full-speed trial, and the combination of turbine and propeller should be such as to give the best economy at the relatively low service speed, even if this involves the sacrifice on the trial trip of the fraction of a knot or so."

The resistances corresponding to a given speed appear to be greater at sea than in trial-trip conditions, according to Professor Biles of Glasgow University. In the case of craft fitted with reciprocating engines, this is not a serious matter, since in general with them the propeller is of ample proportions for the thrust it has to develop. The propellers of turbine steamships, however, are often so small that quite a moderate increase in the thrust to be developed leads to cavitation and consequent large diminution in efficiency. The recent careful experiments made by the United States Navy Department have done much to simplify the problem of combining a turbine and propeller so as to obtain the greatest possible over-all efficiency. The old view, that the percentage of slip is a direct measure of the propeller losses, was again disproved by the Washington experiments. It was found that a high slip ratio, even as much as 40 per cent., is no bar to a reasonable propeller efficiency, which, even with the figure stated, may be 66 to 67 per cent. "It is not improbable, indeed, that this figure might be improved on by giving the propellers an increasing pitch from the front edge to the back. It is known that at low slip ratios there is no appreciable advantage in this procedure, but theory indicates that there might be a substantial gain when the slip approaches 30 per cent. or more. One drawback to the practice would be that the efficiency in going astern would be diminished, and turbine craft are already somewhat deficient in the matter of retrogression.

"Although, as stated, the Washington experiments have simplified the problem of selecting the propeller most appropriate to a given set of conditions, they have pretty conclusively demonstrated the hopelessness of any such improvement in the propeller as will permit of the ordinary reaction steam-turbine being applied to the driving direct of the propellers of the average tramp steamer. If the turbine is to come into general use for such craft, either some form of reduction gearing must be used, or some other form of turbine adopted. An analogous case is found in those water-power plants in which the quantity of water available is small, whilst the head is high. In such cases reaction turbines are never used, as the requisite speed of rotation becomes enormous, but some form or other of impulse turbine working with partial admission. With water such turbines have very high efficiencies; but partial admission in the case of a steam-turbine involves some serious losses, since the wheel has to run drowned. Nevertheless, it is perhaps on these lines that the application of the turbine to small-powered craft will ultimately be developed.

"At first sight the system of partial admission impulse turbines, velocity compounded on the Ferranti or Curtis system, would appear to possess great advantages for marine work in all cases. It is, however, impossible to use as narrow blades with velocity-compounded turbines as with the pressure-compounded type. With the former, provision has to be made for a very great increase in the radial depth of the belt of steam as it flows through the blades, and if the latter are very narrow, this radial expansion, which, it must be remembered, occurs without change of pressure, would be effected so abruptly as to lead to very large eddy losses. Here, no doubt, is to be found the reason for the failure, so far, of this type to show any saving over the Parsons marine pattern in the matter of the weight and length requisite to the attainment of a reasonable economy of steam. . . . . For larger powers, therefore, we think the Parsons

turbine will hold its own; but there does seem a possibility that a combination of the Curtis arrangement for the high-pressure end with the Parsons for the low-pressure might possess advantages in the case of the lower powered and relatively slower vessels. A very detailed study of the problem would, however, be necessary to definitely settle this, as in steam-turbine practice the aphorism that 'general reasoning is generally wrong' acquires an exceptional validity."

HEAT-TRANSMISSION LOSS IN SCALE-COVERED BOILER TUBES.

A SUMMARY OF THE CONCLUSIONS REACHED IN TESTS RECENTLY COMPLETED AT THE UNIVERSITY OF ILLINOIS.

Edward C. Schmidt—Western Railway Club.

THE serious lowering of the efficiency of locomotive boilers due to the formation of scale in the tubes and the consequent loss of heat transmission has led to a large number of investigations on the subject, with a view to determining, if possible, the relations existing between the conductivity and the thickness, hardness and other physical and chemical properties of the scale. One of the most important of these investigations was begun in 1898 in the department of railway engineering of the University of Illinois and a report of the first series of tests was published in 1901. It was felt at that time that additional data were required before general conclusions could be drawn and further series of experiments were undertaken in 1904 and 1905, the results of which are soon to be published as Bulletin No. 11 of the Engineering Experiment Station. A summary of this report was read by Prof. E. C. Schmidt at a recent meeting of the Western Railway Club and the following is an abstract of his paper.

"The tubes were removed from locomotives which had been in operation in various parts of the south and middle west. For each tube the thickness of scale was determined by calipering every 6 ins, of its length. The scale was examined and characterized as either hard, soft, or medium; and for each tube a chemical analysis was made of the scale.

"The apparatus in which the tubes were tested consisted essentially of a long water chamber, through which the tube to be tested was passed, and through which water was circulated. At one end of this water chamber was fastened a combustion chamber with which the tube communicated, and the heat delivered to the tube was supplied by the combustion of gas in this chamber. The heat abstracted from the tube was determined by weighing the water which passed around the tube and through the water chamber, and by noting its rise in temperature. For each series of tests the gas and air needed for combustion were delivered to the burner at constant pressure for all tests, and in approximately the same amounts.

"After adjusting the supply of water to the water chamber, the burner was lighted and the flow of gas and air regulated to the desired amounts. The apparatus was then allowed to run until all conditions had become stable. This usually required about one hour, at the end of which period the test was started. Observations were taken, at 5 or 10 minute intervals, of the temperature of the gases at entrance to the tube and at exit, as well as of the water temperature at entrance and exit of the water chamber. The amount of water used was determined by weighing. The purpose of the tests was to determine the number of thermal units transmitted per hour through each tube. This equals the weight of water circulated multiplied by its rise in temperature.

"When the experiments were planned it was considered probable that the transmission of heat through the scale was principally dependent upon two of its characteristics, namely, its thickness and its mechanical structure, and that probably, for such thicknesses as are usually met with, thickness had greater influence than structure. Thickness was therefore carefully determined and structure approximately designated as hard, soft or medium, no more exact characterization of structure being

possible with tubes collected from different sources.

"It was hoped that the experiments might develop, if perhaps only approximately, some law of variation of conductivity with thickness. After making allowance for possible errors due to the method of conducting the tests, the result shows perhaps a decrease of conductivity with thickness; but certainly no regularity of variation. No regularity of variation is observable with respect to hardness or softness.

"It must be borne in mind that the tubes tested were taken from locomotives which had been in service in different parts of the country and that the scale on each tube was made up of the mineral constituents of many different water supplies. What was designated as hard scale in one case may be very different in structure (in porosity, for example) from that designated as hard scale on another tube. The results cannot therefore be considered as providing conclusive evidence concerning variation of conductivity with structure. They may properly be interpreted as indicating that mechanical structure is at least as important a factor in the change in heat transmission due to scale as is the mere thickness. Such a conclusion is, of course, in accord with the facts concerning other heat insulators."

It seeems probable that soft, porous scale would more effectively retain against the tube surface a layer of water or vapor of low conducting power, and we should accept with caution the assumption that hard scale will cause a greater loss than soft scale. The diagrams in which the loss in heat transmission is plotted with reference to the principal chemical constituents of the scale, do not warrant the conclusion that its chemical composition has any direct influence on its conductivity.

"Conclusion.—In so far as generalization is warranted we may sum up the results of the tests in the following conclusions:

1. Considering scale of ordinary thickness (say varying up to ⅛-in.) the loss in heat transmission due to scale may vary in individual cases from insignificant amounts to as much as 10 or 12 per cent.

2. The loss increases somewhat with the thickness of the scale.

3. The mechanical structure of the scale is of as much or more importance than the thickness in producing this loss.

4. Chemical composition, except in so far as it affects the structure of the scale, has no direct influence on its heat transmitting qualities."

NATIONALISATION OF RAILWAYS IN FRANCE.

THE SIGNIFICANCE OF THE RECENT PURCHASE BY THE GOVERNMENT OF THE WESTERN RAILWAY OF FRANCE.

Engineering.

GOVERNMENT ownership of railways, which is being so strongly advocated in both England and the United States at the present time, has been for many years the principal and most convenient plank in the platform of the French Socialist party. It has been urged repeatedly that the working of the railways by the companies forms a costly luxury, paid for by the people indirectly, and resulting directly in the application of high rates for carriage and transport, whereas State ownership would yield immediately numerous advantages and lower tariffs. French railroads have never been independent of the State but have operated their lines under a leasing system. State subsidies were secured for construction and State aid in the form of loans was granted them until they were able to meet their obligations out of their profits. The government-ownership party declared at the time this system was introduced that the railroads would never be able to pay back the loans but would forever remain debtors of the government and they advocated the purchase outright of all the French railways by the State. Time has not fulfilled their predictions. The railroads have been gradually increasing their strength and reducing their obligations to the government and the recent purchase of the Western Railway of France was consummated through the endeavors of the socialist par-

ty to prevent the removal of their last argument in favor of government ownership. The following review of the railway situation in France is taken from a recent number of *Engineering*.

"The leases granted to the railway companies in France are not perpetual leases. At the commencement, in 1842, they were very short; later on they were increased to 99 years; and now, owing to modifications which have been carried out in the distribution throughout the country of the various networks, the leases of the six companies working the larger systems are to terminate between 1958 and 1960. By the leases in question the State grants to the companies the working of the lines; the State bears the cost of the necessary road-bed, the companies having to take charge of the superstructure and of all the subsequent improvements and alterations required by development in the traffic. But among the concessions granted, many were for lines which were not likely to become paying lines for several years; the companies had, therefore, to face a financial crisis, owing to their heavy outlays. The Government helped them in this crisis by giving guarantees of interest, or, in other words, by lending to the companies a sufficient annual amount to cover interest and provide for repayment of loans. These State aids were in the shape of loans bearing interest, to be refunded when the profits of working exceeded the amount guaranteed; the State further was to share in the profits after collection of its debts, when the dividend exceeded a given percentage. In 1883, after having leased to the companies a number of new lines, or, more accurately, after having compelled them to build a number of non-paying lines, a very large programme of public works was started absolutely out of proportion with the State resources and with the results which might be expected from it. The object was to build harbours and ports at numerous places round the coast, canals in every direction, and new lines in sufficient number to satisfy even the most exacting voter. In the matter of railways, in particular, the State had then the ownership of a number of isolated lines which it had built and hardly knew how to work profitably; further, it was at a loss to find the necessary funds to build the new lines promised right and left—lines costly to build, and without any immediate future whatever. The State promises had to be kept; for this assistance had to be found, and the companies were therefore requested by the State to take charge of the non-paying lines in question, and to connect them up to their systems by other non-paying branch lines. The railway companies at that time were becoming firmly established on good financial bases, and were commencing the repayment of their loans and guarantees of interest above alluded to, except in the case of the Western of France Railway, whose system is, no doubt, less profitable than the others.

"This led to what is called in the French railway world the 'Conventions of 1883,' which conventions, the Socialist and monopolist *députés* assert, were entered into for the sole benefit of the companies, whereas, in truth, they were attended both by advantages and disadvantages, which, it was hoped, would balance each other within a comparatively short period, and finally result in benefiting the whole country. At all events, these Conventions had the effect of solving a difficult financial problem for the Treasury. The Conventions, of course, meant the conclusion with the companies of a new contract ensuring further State guarantees of interest applicable to the working of the indifferent lines to be taken over and connected up, but they also meant that the companies had to lay out large sums for construction purposes; the companies helped the State by undertaking, under compulsion, what the State was unable to take in hand for the time being. For this the companies issued loans in their own names, the State giving its guarantee in the usual way; but the guarantee under the conventions of 1883 has always been held separate from that given previous to the conventions. When the latter were entered into, there were good reasons to believe that State aid to the railways would soon become unnecessary; the date on which the companies would have paid off their debts to the State was also in view, and from that date the State was to commence receiving, when the railway profits exceeded a given sum, two-thirds of the amount in excess.

"Immediately after signing the Conventions of 1883, the country had to face an industrial and agricultural crisis, the effect of which was largely to reduce traffic. The net profit of the railway companies became insufficient to pay the guaranteed interest, owing to the fresh outlays they had to face by reason of the new lines that were forced upon their systems. The companies were compelled to have recourse for a long period, and for heavy sums, to the guarantee of interest granted by the State. Members opposed to the Conventions, and to the private working of the railways, concluded therefrom that the Conventions would never yield a satisfactory result. Gradually, however, and while the monopolists were publishing their adverse opinion, the situation was improving steadily, the companies were making less demands upon State aid, and were reaching the refunding period. The Western of France Railway alone still requires State aid to compensate for the insufficiency of its net receipts. But the situation as regards this company is also improving in a natural way, and it may be assumed that it would soon reach the favourable status of the other companies. This favourable status would continue for all, the State sharing the profits until the whole of the systems became State property on expiry of the leases.

"Among the most militant exponents of State enterprise in this respect may be mentioned M. Pelletan, whose policy as Minister of Marine was fraught with such evil consequences for the French Navy, and other *députés* who have argued throughout the land that the companies would never be able to reduce their liability to the State and to the rate-payers; but would, on the contrary, increase it year by year. A few years ago M. Pelletan, and those members who hold his opinions, asserted that all the French railway systems, with the exception of the Northern of France, were bound to remain forever debtors of the Budget, and they advocated the purchase by the State of the whole. As time went by, facts have contradicted their assertions, and they have been obliged to curtail their proposed programme, and to claim the redemption of only part of the systems, those which, to their showing, would never improve their status. But their later prophecies also have not come true, and the members in favour of State monopolies have hastened to obtain from the Lower House a vote providing for the nationalisation of the Western system, because this system was on the point of entering on a more satisfactory phase, thus destroying totally the arguments in favour of State enterprise. Formerly M. Pelletan advocated, with much emphasis, the redemption by the State of all the railways, except the Northern of France; later, in 1900, the Western, Southern, Eastern, and Orléans were alone on the tapis; in 1902 there remained but the Southern and Western; finally, in 1905, the Western alone was in question, because, in the case of the Southern, matters have improved sufficiently to quash all arguments in favour of State working.

"A fact which the monopolists willingly ignore is that State assistance has not been promised to the companies up to the time the leases expire, but only up to twenty-five years before their expiration. The debt of the companies to the State would at all events cease to increase twenty-five years before the expiry of the leases, were the companies unable then to commence reducing it. But, as we have stated, the companies have commenced refunding to the State the money lent them by the State as guarantee of interest. In 1904 the Eastern of France and the Paris Orléans Railway repaid the State 3,000,000 francs (120,000*l.*) each; repayment by the other debtor companies still goes on regularly. The Western of France Railway still borrows State subsidies, and in the case of this company the receipts are on the increase, and repayment to the State would soon commence. The latter is what the monopolists want to forestall.

"If the purchase of the Western Company is completed, it will not be possible to prevent the shareholders from reaping the advantages they have a right to by reason of the Conventions of 1883, and in exchange for the services they have rendered to the State Treasury. These Conventions contained conditions advantageous to the State, and others profitable to the companies, who became in a sense bankers to the State. If the State wishes to acquire the system before the natural expiration of the

lease, it has to pay annually until the end of the lease (and not until the date on which its guarantee terminates) a sum equal to the revenue which the State deprives the company of, and corresponding to the average of net receipts, based upon a mutual agreement. But this sum must be, at least, equal to the revenue guaranteed by the State. Therefore, if the company could show receipts high enough to exceed what the State had guaranteed as minimum profit, the Treasury would have to pay the company, until the expiry of the lease, a sum exceeding that which the State lent when the company was not in a very favourable situation. It is true that in these circumstances the State would be working the system, and would collect the receipts, but experience in the matter of State control of railways tends to show that the receipts in such an event would be less than those of a company, even were the latter badly managed.

"By purchasing the Western, or the whole of the railways now, the French Government would pay dearly for the right of acquiring immediately a property which is to revert free to it later on."

A NEW ALPINE TUNNEL PROJECT.

DETAILS OF THE PROPOSED SPLÜGEN PASS RAILWAY BETWEEN SWITZERLAND AND ITALY.

Schweizerische Bauzeitung.

THE natural territorial boundaries between Italy and the countries lying to the north of it could be crossed formerly only by means of the passes or defiles over which "diligence" routes were maintained. But recent years have witnessed the completion of the Mt. Cenis, St. Gotthard and Simplon railway tunnels, and still the demand exists for more means of communication between Italy and Switzerland. It is very noticeable in this connection that a large and an increasing share of the traffic, both passenger and freight, traversing the existing Alpine tunnels is through or long-distance traffic, not only to and from the large cities of Switzerland, but also from the railway centers of Germany and Austria to all parts of Italy. To this steady, all-year traffic is added the enormous number of tourists that for three months in every year tax the railway facilities of these lines as well as those of most of the other European railways. It is, therefore, not surprising that a concession was granted a few months ago by the Swiss and the Italian governments for the construction of a railway from Chur, in the eastern part of the former country, to Chiavenna in the northern part of Italy. The project is not a new one, as several locations for such a line have been made within the past five or six years. That which seemed to have the greatest promise, though having to encounter steep grades, gives a short line of only 52 miles between the points named. A recent issue of *Schweizerische Bauzeitung* gives an account of this project, on which work is about to begin. The plan of the work and the credit of the location and surveys are due to Dr. Eduard Locher-Freuler, a Swiss engineer.

The line has been chosen, among other reasons, because it will afford the shortest route between the cities of northern Italy and the Engadine, Tyrol and Vienna, as well as the central and southern part of Switzerland. Beginning at Chur, the railway will parallel for a short distance the lately completed Rhaetian railway, then run in a southerly direction through Rothenbrunnen, Thusis and Andeer. At the latter place a tunnel will begin, carrying the line under the well-known Splügen pass, from which the railway takes its name, into Italian territory and on to Chiavenna, where it will connect with the existing railways to Milan, Venice and Genoa. The northern end of the line, from Chur to Rothenbrunnen, will be operated by steam locomotives, although there are two short but steep grades, 7 and 10 per cent. For the remainder of the distance, about 42½ miles, electric motors will be required, the steep grades and the long tunnel precluding the use of steam locomotives. A short distance south of Rothenbrunnen a steep ascent begins, the ruling grade being 26 per cent., and the line is carried constantly higher until Andeer station is reached at

a height of 3273 feet above sea level, and 1344 feet higher than Chur, a rise of 1393 feet in 22 miles. At Andeer a tunnel 16¼ miles in length will be run through the Alps, and about half of this will be on an 18.5 per cent. grade against the northbound trains. The tunnel will have only one track, but there will be two passing sidings, each 1640 feet long. From Andeer south there will be a 3 per cent. grade for four miles, at the summit of which the international boundary will be crossed, after which the steep descent begins into Italian territory. From Callivaggio, at the south portal of the tunnel, the grade will be almost entirely descending at from 23 to 26 per cent. until the terminus is reached at Chiavenna. As the south, or Italian, portal is about 650 feet lower than the north end of the tunnel, it is expected that there will always be a strong air current through the tunnel which will provide natural ventilation and at the same time, being unusually dry and having a high capacity for moisture owing to its high temperature, the air will maintain the rails in a sufficiently dry condition to afford the necessary tractive adhesion of the wheels. This result could not be obtained if the same grade were attempted from the north end, because the rails in the tunnel would always be wet.

The project is certainly bold, in spite of present-day attainments in engineering, and it will furnish enough problems to the designers and builders of the electric locomotives to class it as out of the ordinary. The estimated cost seems appalling, $24,841,000—for 52 miles, or at the rate of $477,000 per mile. This, however, means a completed railway, stations, permanent way, rolling stock and signals; and taking into consideration the character of the undertaking and the quality of all work done by European engineers, it is probably a very fair estimate. It is stated that ample power for the operation of this railway has been secured at sites on certain streams on the Swiss side of the Alps, in addition to which, as a reserve, it is probable that a plant will be established near Chiavenna, in the vicinity of the south end of the tunnel. While no definite announcement as to the kind of electric system to be used has been made as yet, the trend of European practice for heavy railway work is strongly in the direction of the three-phase alternating current; and it will not be surprising if this is adopted in this new project.

GYROSCOPIC STEADYING APPARATUS.

TESTS OF THE EFFICIENCY OF THE GYROSCOPIC ACTION OF A ROTATING FLY-WHEEL IN CHECKING THE ROLLING OF SHIPS.

Sir William H. White—Institution of Naval Architects.

SOME months ago a review in these columns discussed the gyroscopic apparatus for the steadying of ships, designed by Dr. Otto Schlick and explained the theory on which the design was based. At that time investigations had been carried out only on small models, but recently a highly important and successful series of tests was concluded on a ship of fairly large size on which Dr. Schlick's apparatus had been installed. At the request of Dr. Schlick, the results of the tests were communicated to the Institution of Naval Architects by Sir William H. White, who was an eye-witness of the experiments, and the following extracts are taken from a paper read by the latter at a recent meeting of the Institution.

The vessel on which the tests were carried out was the See-bar, formerly a first-class torpedo boat of the German navy, of which the principal dimensions are as follows:

Length at the water-line.....116 ft.
Extreme breadth .....11.7 ft.
Mean draught .....3.4 ft.
Displacement .....52.2 tons.
Metacentric height .....1.643 ft.
Period of oscillation (double roll, with gyroscope at rest).....4.136 secs.

The gyroscope was placed in a compartment immediately forward of the boiler-room. As no electric power was available, steam was used and the flywheel was worked as a turbine, the periphery being provided with rings of blades and the

whole being enclosed in a steam-tight, cast-iron casing. In order to minimise practical difficulties which might occur in carrying out the experiments, it was decided to keep the speed of revolution of the wheel relatively small, and to make its diameter correspondingly large. The following dimensions were finally adopted:

Outside diameter of fly-wheel.....1 metre.
Weight (without spindle).....1,106 lb.
Peripheral velocity per second.....274.8 ft.
Revolutions per minute.....1,600.

"The fly-wheel was made of forged steel in one piece. The cast-iron casing containing the wheel is carried on two hollow horizontal trunnions, their axis lying athwartships. These trunnions have ball-bearings. The steam supply and discharge take place through the trunnions in the same manner as in an oscillating marine engine. The lower end of the spindle of the fly-wheel is carried on ball bearings, and there is forced lubrication to both upper and lower bearings. At the upper end of the spindle a centrifugal regulator is fitted, by means of which the steam supply is cut off if the revolutions per minute exceed 1,600. In addition there is an appliance by which a bell is rung after every 10 revolutions of the fly-wheel, in order that the engineer may readily check the rate of revolution.

"The common centre of gravity of the gyroscopic apparatus—fly-wheel and casing—is arranged to lie below the axis of the trunnions. When the vessel is at rest, in an upright position, the spindle of the fly-wheel will be vertical. When the vessel is set rolling, the spindle of the fly-wheel is free to become inclined to the vertical in a fore-and-aft direction. As rolling proceeds the gyroscopic effect of the fly-wheel produces longitudinal oscillations of the apparatus. The period of these oscillations depends, of course, upon the distance of the centre of gravity of the whole apparatus below the axis of the trunnions, and upon the moment of inertia of the apparatus about that axis. The amplitude of oscillation of the gyroscope depends upon many and varying conditions, amongst which the period of oscillation and its ratio to the period of rolling of the vessel are important. It is most interesting to watch the movements of the gyroscope, when it has been set free and is exercising a steadying effect upon the vessel. The observer may be standing upon a deck that maintains a practically horizontal position as the vessel performs vertical heaving oscillations; but the gyroscope meantime may be oscillating violently to and fro in the longitudinal sense, and the observer watching it may have the impression that the vessel herself is moving.

"It will be understood that great importance attaches to the existence of efficient arrangements for controlling and 'braking' the movements of the gyroscope on its trunnions, and the rotary movement of the fly-wheel. In the See-bar this matter has been carefully studied, and experiment has shown that the brake arrangements are thoroughly efficient. A simple band-brake is fitted on the port side, and is worked from the deck above, in order to control the swinging motion of the apparatus on the trunnions, or to hold it at rest. In addition there is a socket fixed on each side of the gyroscope-casing below the fly-wheel, which carries an hydraulic brake-cylinder, the piston-rod lying fore-and-aft in the vessel. The braking-power is regulated by a valve workable in the gyroscope compartment, and from the deck. This hydraulic brake answered its purpose well, but in electrically-driven gyroscopes a different design would be adopted, involving less space and weight.

"When the apparatus was used in experiments at sea, the fly-wheel was set running while the casing was held fast by the friction-brake in its central vertical position, and the revolutions were brought up to 1,600 per minute. Observations were made at first with the casing fixed; in which condition, of course, the gyroscope had no effect on the rolling motion. After a sufficiently long period of observation in this condition had elapsed to enable the 'phases' of rolling to be determined, the friction-band was loosened, the casing began to oscillate on its athwartship trunnions, and the gyroscopic action came into play. Another series of observations of rolling was then made, and the steadying effect of the gyroscope was ascertained by comparing the two series of observations."

Before making any experiments on the steadying effect of the apparatus, the work-

ing of the gyroscope was tested with the ship still at her moorings. The apparatus was found to work satisfactorily, no shock or vibration was observable, the arrangements for braking proved efficient, and the fly-wheel was speeded up to 3,000 revolutions per minute without any bad effects. Still-water rolling experiments were undertaken next, the motion being produced by running the crew from side to side of the deck. With the gyroscope fixed, the period of a complete double roll was found to be 4.136 seconds. When the fly-wheel was running at 1,600 revolutions per minute the corresponding period of oscillation was found to be 6 seconds—an increase of 45 per cent. Owing to the small size of the deck, only small angles of heel were attained by this method of producing motion and greater angles of inclination were produced by heaving the boat over by means of a chain from a crane, made fast at one side of the boat and fitted with a slip-hook. At inclinations of from 10 to 15 degrees from the vertical, the chain was suddenly let go and successive extreme inclinations were noted until they fell to about 0.5 degree. These experiments strikingly illustrated the enormous extinctive effects of the gyroscope. For example, with an initial angle of inclination of 10 degrees, 20 single oscillations took place before the extreme inclination to the vertical was reduced to half a degree, the gyroscope remaining at rest; while the same amount of extinction was obtained with little more than two single oscillations when the gyroscope was free to oscillate and the fly-wheel was running at 1,600 revolutions per minute. In another case, when the initial angle was 13 deg. 40 min., 25 single oscillations were required to limit the inclination to half a degree from the vertical when the gyroscope was at rest, but only three when the gyroscope was free and the fly-wheel running at 1,600 revolutions.

Experiments undertaken in the sea-way were fully as conclusive. Considerable difficulty was experienced in obtaining a sufficiently rough sea in which to make the tests, but on two days on which conditions were favorable, excellent results were obtained. In all cases the practical effect of the gyroscope was to extinguish the rolling motion almost immediately. With the gyroscope free to oscillate and with a rotation of 1,600 revolutions per minute, the See-bar was practically deprived of rolling motion and simply subjected to heaving motion as successive waves passed her as she lay broadside on to the sea. One set of observations gave maximum inclination on each side of the vertical with gyroscope fixed, 15 degrees; arc of rolling, 30 degrees; with gyroscope oscillating the arc was reduced to one degree within a very short time.

"The gyroscope fitted in the See-bar was intentionally made relatively powerful for purposes of experimental illustration. The proportion of the weight of the fly-wheel in that case to the total weight of the See-bar was as 1 to 114. The proportion of the moment of inertia of the fly-wheel to the moment of inertia of the whole boat about a horizontal longitudinal axis passing through the centre of gravity was approximately as 1 to 1,156. In order to obtain experimental data which should be of value in further designs of gyroscopes, it was decided to make an experiment with the See-bar with the fly-wheel running at less rates of revolution than 1,600 per minute. When the revolutions were reduced to 1,200 no sensible difference was observed in the steadying effect; at 1,000 revolutions per minute, a slight reduction in the steadying effect was remarked. At 800 revolutions, under conditions when inclinations of 12 deg. on each side of the vertical were observed with the *gyroscope fixed,* rolling was reduced to 3 deg. on each side of the vertical when the gyroscope was free to oscillate. This last trial showed that when the moment of inertia of the fly-wheel was only *one-fourth* of that provided for in the design of the gyroscope of the See-bar, a considerable reduction in rolling was produced. It has been stated above that the number of revolutions of the gyroscope fitted in the See-bar were raised to 3,000 per minute in the preliminary trials, and that no bad results followed. Experience with the wheels of steam turbines also shows that it is possible to work at much higher peripheral velocities, provided suitable designs and materials are adopted. With a peripheral velocity twice as great as that used on the

See-bar, the same effect could be obtained with a fly-wheel of 2.3 ft. diameter as was obtained when the actual fly-wheel fitted ran at 1,600 revolutions per minute; and it is evident from the trials made at reduced rates of revolution that a wheel of only 2 ft. in diameter would have given as great a steadying power as was required in practice. These facts are of great importance in considering possible applications of the system to larger vessels. Such installations would include electric driving as well as improvements in lubrication and in the design of the brakes. Dr. Schlick has already done much work in these directions; he is convinced that the system may be applied to larger vessels in forms that would secure considerable steadying power; while the requirements for weight, space and motive power would be kept within such moderate limits that they could be accepted by shipowners."

The experiments indicate great possibilities for the system, but Sir William considers that it will be wise to proceed gradually. In modern steam yachts and small coasting steamers, gyroscopic apparatus could be installed with no inconvenience and with excellent results. In ocean-going passenger steamers the advantage would not be so marked as this class of vessels are remarkably steady at sea on account of their large size. In war-ships, however, the advantages would be numerous and we may expect to see the device applied to destroyers and cruisers in the near future as the tendency in design is to obtain the greatest possible stability and steadiness for these vessels, especially to secure steady gun platforms.

RAIL CORRUGATION.

A DISCUSSION OF THE INFLUENCE OF DEFECTIVE ROLLING STOCK IN CAUSING CORRUGATION OF TRAMWAY RAILS.

Joseph A. Panton—Institution of Electrical Engineers.

THE question of the corrugation of tramway rails is one of the most perplexing with which the traction engineer has to deal. Though the subject has been discussed at great length and on many occasions, no adequate theory as to the cause of the trouble has been evolved and there are almost as many different opinions on the subject as there are tramway officials.

Unsuitable rail material, chemical action upon rails, fatigue of rails due to excessive loading, slipping of braked wheels, are a few of the theories which have been offered in explanation of the phenomenon, only to be rejected as being applicable to but a limited number of cases. In a paper read at a recent meeting of the Institution of Electrical Engineers, Mr. Joseph A. Panton advances the theory that the trouble is due entirely to defective trucks and an outline of his argument is given in the following abstract.

"Seeing that the actual corrugations occur on the rail, it is but natural to suppose that their presence or absence depends on the quality of the rail. The author has come to the conclusion that no satisfactory evidence has yet been put forward in support of this view. In fact, enough evidence has now accumulated to contradict any rail theory that might be promulgated. The following, amongst others, are reasons why the rail theory fails to account for the presence of corrugation:—

1. Because rails manufactured by every firm in the world have corrugated since the advent of electric traction.

2. That the rails did not corrugate in the days of horse and steam cars.

3. That the check rails are corrugated to an equal degree, and parallel to that on the crown of the rail.

4. That rails did not corrugate so long as the armatures were built on the axle.

5. That it takes on the average three years to develop corrugations on a new system, and only three weeks on relaying with new rails thereafter.

6. That an ordinary railway rail taken from the straight road of an electrically-operated railway (where no corrugations occur), and relaid on a checked curve soon corrugates.

"Further, corrugated rails have been

tested, and found to contain all the chemical constituents, and to possess the physical qualities required of them. It has been said that the trouble is due to the chattering of the rollers at the rolling mills, owing to play in the pinions and bearings of the rolls driven by antiquated steam engines. For the sake of argument, assume this to be so. Why, then, is it that the rails on electrically-operated railways only corrugate on checked curves, the remaining seven-eighths of the track being perfect? And why does it take so long to corrugate tramway rails on a new system, and so short a time on renewals? And why are not corrugations found on our steam railroads, running at 60 miles per hour? Further, in this country and abroad we find corrugations 24 inches to 30 inches in wave length. If chattering is going on in the Middlesbrough rolls on so gigantic a scale, the noise of it should be audible for miles around.

"The author's attention was first drawn to defects in rolling stock as a means whereby corrugation might be caused, by the action of a flanged brake block then being tried to keep down wheel flanges. The tendency of the flanged brake blocks was to cut into the outer edge of the wheel tire, and it appeared difficult to account for this peculiar action. Later on it occurred to the author that the bogie truck frame and the wheels were not acting in unison, especially when rounding sharp curves. The bogie-truck frame, by means of the hangers, communicated to the brake block a twisting movement, which caused it to cut the wheel tread. On reverting to the brake block without a flange no cutting occurred, but by judicious watching it soon became apparent that this block had a decided tendency to run off the wheel tread on one side, and cut into the flange on the other. On further examination, it was found that the frames were out of square and the axles out of line; this was due probably to the axle being geared at one end of the shaft only, the tendency being to form diamond-shaped truck frames. To prove this remarkable result of defective gearing, the author has only to draw attention to the case of the Liverpool Overhead Railway during the first nine or ten years of its existence, when the armatures were built on the axle, whereby a symmetrical drive was obtained. During this period, there was no sign of any corrugations. On introducing single-ended geared axles into the same bogies, a series of difficulties cropped up when running over the same rails, necessitating the renewal of rails on checked curves.

"Many similar cases have occurred on tramway undertakings where the conversion from steam to electric traction over the same rails has brought about corrugation. Being geared at one end and mounted in a weak truck frame, the whole tendency is to push the frame out of square, and the axles out of line, and as an examination of the wheel tires clearly indicates, a grinding action takes place between the wheel flanges and guard rails. The wheels soon become groove-locked when speed is attained, and the wheel flanges striking the check rail intermittently cause the whole axle to jump or oscillate in the groove, giving rise to intermittent skidding and producing the peculiar flattening of the rail, known as corrugation. Corrugations will also be found on the check rail, equal and parallel to those on the crown of the rail, which clearly demonstrates that the wheels oscillate in the groove. This soon brings about unequal tires on the same axle, which causes a momentary slowing or lagging behind of one tire, and this still further increases the tendency to locking of wheel tires, as can readily be seen by the severe indentations on the check rail, each indentation tapering off to nothing as the tire is freed. Immediately the tire is freed it jumps forward the required distance to bring it into line, producing a sort of case-hardening effect on the head of the rail which remains high, and as it is at the same time revolving, in doing so it scoops or grinds intermittent hollows in the rails, the wave lengths being determined by the speed of the car and elasticity of the track. In the matter of wheels we have clung to old practices longer than might have been expected, having made few changes in their dimensions or contour, a matter which requires immediate attention; for as we have considerably increased the speed and weight of cars, the tread and wheel flanges ought to be suitably modified to adapt them to the new

conditions. Again, the running of a ¾-inch thick flange in a 1-inch wide groove requires further consideration, especially when rounding curves.

"A large percentage of the trucks under our street cars are not capable of meeting modern requirements, because of the inability of the frames to withstand side strains. Such trucks may be cheap at the beginning, but constantly require repair, while at the same time they need more current to draw them, and are most expensive in the end. The present-day bogie-truck frames of rivetted and built-up construction, as used by most electric railway companies, carry the load in the centre, and are themselves supported upon equalising springs instead of on journal springs. This gives a short spring base for the frame, and in consequence, when the brakes are applied, the frame is pulled down at one end and pushed up at the other. The author has noticed frames tilting 3 or 4 in., bringing the life-guards down on the rail.

"The equalising bar bears directly upon the axle box, and when the horn slides are worn the boxes take up a rigid position at an acute angle to the jaws of the frame causing a binding of the boxes, and producing the vibration so noticeable in trucks of this design. It is, therefore, necessary to give up the riveted and built-up construction of bogie frames on modern high-speed electric railways. It is the weakness in bracing the two sides together, especially under the axle box, that makes the present-day trucks unable to withstand the severe side strain they are subject to. It will, therefore, be necessary to supplement the present trucks with suitable under-frames well braced on either side of the wheels. In the author's opinion, the time is not far distant when we shall have brake blocks on either side of the wheel, especially for street traction. The difficulty with horn slides would then be obviated. Some careful observations have been made with reference to the effects of retardation on the rails. With heavy electric trains running at 40 to 60 miles per hour, only barely visible wavy skin depressions appeared on the rails after a hard application of the brakes, the depressions being distorted and finally obliterated by the next train. Sudden braking operates unfavourably on the superstructure, in the sense that the rails are subjected to vibration, and consequently the sub-structure gets separated, but this action has gone on for years at the same place without creating any impression upon the head of the rail. There is, therefore, no ground for assuming that the application of brakes has any connection with corrugations or roaring rails."

HARDENING ROADS BY SURFACE APPLICATIONS.

A REVIEW OF THE METHODS USED TO REDUCE DUST ON HIGHWAYS CARRYING HEAVY TRAFFIC.

J. W. Howard—American Road Makers' Association.

THE suppression of the dust of roads has become a necessity from both a hygienic and an economic standpoint. Flying dust carries disease germs which are a constant menace to the public health, and it works incalculable damage to food products in transit, to crops, to real estate values, besides entailing a constant loss of road material. The road dust problem is, therefore, receiving a great deal of attention from engineers in all civilized countries. At a recent meeting of the American Road Makers' Association, Mr. J. W. Howard outlined the various methods which are used for hardening roads by surface applications, and the following abstracts are taken from his paper.

"The following are the general methods in use for reducing dust. Each method more or less retains or agglomerates the dust already formed or prevents its formation:

1. Sprinkling roads with fresh water.
2. Sprinkling roads with natural salt water.
3. Sprinkling roads with mixtures of water and calcium chloride.
4. Sprinkling roads with mixture of water and saponified oil.
5. Impregnating roads with special crude oils.
6. Impregnating road surfaces with special coal tar products"

Sprinkling with water is at best only a

temporary help, and, besides being impossible on thousands of miles of roads, when done continuously on short stretches it costs more than any of the other methods. Salt water is, of course, available only near the ocean. Its use gives rather better results than that of fresh water, because the salt accumulates on the road and absorbs moisture. When dry, however, the salt hurts the throat and eyes, damages clothing and furniture, and has rather serious effects on the feet of horses.

Sprinkling with a solution of calcium chloride is related to sprinkling with salt water, both methods being based on the principle of a hygroscopic salt. To produce the best results on macadam roads, about three pounds of the salt are required per gallon of water. In one case, good results were obtained by sprinkling three times the first month and twice each subsequent month at a total cost of about 10 cents per square yard. The calcium method is a temporary help at a few places, but it is expensive and out of the question for general use. The saponified oil method is used in Europe to a certain extent and there are several patented compounds on the market for this class of work. But all these soapy compounds are of doubtful value for use in America where substances which are durable and require attention only at long intervals must be used.

"The application of certain oils to roads practically began in California in 1894, when crude-oil from the Summerland oil wells was used on the Ortaga Road five miles from Santa Barbara. It was sprinkled to lay the dust of the soft soil of the road. A slight hardening of the road was observed from the repeated applications of the thick maltha or asphaltic oil. A few other roads in California were sprinkled until about 1900, when the use of its oils on roads rapidly extended from the many oil centers in that state, until to-day, oil is used for suppressing dust and hardening roads, with varying success and failure, in about 40 counties of California to an extent of a little more than 2,056 miles. * * * * * *

"Probably the best constructed and maintained oiled road of California is the driveway of Golden Gate Park near San Francisco. The oil when cold is between 14 and 16 degrees Beaume. It was heated to about 300 degrees F.; sprinkled while hot on the road; men followed closely and stirred the oil into the road with rakes. The road of course was first properly graded and shaped. Its surface was made smooth, then soaked with water to loosen it. It was next well dried to a depth of at least 1 inch and the oil applied as stated during warm dry weather. Repairs are constantly made by promptly sweeping out any little hole that forms, putting in a little oil, adding gravel and stone dust to absorb the oil and tamping until firm. The oil costs 72 cents per barrel and 400 barrels per mile of 16-foot road were first applied. Since then 300 barrels per mile have been applied twice each year or 600 barrels per year. The tendency is to form into ruts and a slight lowering of the whole road surface. This last is caused by rain water working through the surface and carrying away the road material from under the asphaltic oil crust. Although expensive, it is so important a drive out of San Francisco that it is worth all its costs. * * * * * *

"Road materials, which if wet, would pack firmly under roller or traffic and still remain slightly porous, are the materials which are the best for use by saturating with suitable thick adhesive oils. Such oils suppress dust and harden such a road. Road materials of certain clays, earths and gravels which, when wet, pack tight or bake in the sun and which pulverize into dust, must be either loosened up by harrowing or otherwise made porous before being oiled, and then must be covered with sand, screenings or the material of the road. Oiling roads is a case where a little knowledge is dangerous, and where much knowledge and experience must be employed to select suitable oils and to use them correctly. * * * * * *

"The use of coal tar and its products as ingredients of pavements and roads has been undertaken in many ways for about fifty years, but with no success until quite recently. The tarring of a macadam road means sprinkling, painting or covering its surface with a soft tar specially prepared for that purpose, and which will penetrate the macadam and make it waterproof and retard the formation of mud and dust. A prepared tar which is sufficiently fluid to lay dust and penetrate the surface of the

macadam cannot be a binding material to hold together any portion of that macadam except the finest particles and dust.

"Specially prepared coal tar, by surface application on macadam to eliminate dust and make the macadam waterproof and more durable, first succeeded in Melbourne, Australia, in 1886, where the experience gained has been followed by constant use ever since. Tar freed from water and very light oil and otherwise improved is used. The macadam is first well bonded and consolidated, then tarred and fine stone screenings are spread. Coal tar products are suited to hard macadam and similar roads, because it is not practical and economical to use these products on soft earth, clay and sand roads. The cost would be too great, sufficient tar is not available, it would not harden. It is better and cheaper, where obtainable, to use suitable asphaltic oils on soft and absorbent roads. * * * * *

"The Vendee District, France, based on records begun in 1896, shows as follows: One highway 20 feet wide was tarred in the following manner: The macadam was put in good condition, well rolled and used by traffic for a month; then thoroughly cleaned by stiff brooms, followed by fine brooms. Hot tar was spread over the macadam. It percolated down into the macadam, the work being done in warm weather with the road very dry. It penetrated 1 inch in four hours, and 1⅔ inches in twenty-four hours. The first tarring required about 1.9 pounds per square yard. Twelve hours after tarring each section, clean sand was spread. The surface was then rolled and opened to traffic.

"One year later the operation was repeated, using less tar, because the road would absorb less; then every second year thereafter. The road was practically free from dust, its wear was reduced to about one-half and the total cost of the road in ten years was 40.4 per cent less than under the old system of maintaining the road in constant good condition with macadam only. This was due principally to the fact that the tar saved $1,430, which would have been paid out during the ten years for extra crushed stone and resurfacing, if the surface had not been tarred at intervals as stated. Tarring made it necessary to resurface with stone only once, not twice, as formerly. A second road in the same district properly tarred costs 23 per cent less on a basis of fourteen consecutive years than if it had been maintained with macadam only. * * * * * *

"The work should be done only in warm, hot and dry weather. The macadam should be first swept clean and sometimes washed, but should be allowed to become perfectly dry to a depth of at least 1 inch before applying the tar product. The tar should be spread uniformly under competent supervision. It should be allowed to stand and percolate for at least several hours after being spread and then be covered preferably with sand or with uniform fine grained stone screenings, containing no earthy matter or dirt. The tar should be applied as hot as possible at about 200 degrees F. After the sand or screenings have been spread, it is best to wait several hours before rolling with a steam roller. During the rolling additional sand or screenings must be added if any tar squeezes up through them. It is a good plan to keep traffic off of the finished rolled road for a short time after rolling."

HYDRO-ELECTRIC POWER PLANTS IN EUROPE.

EXAMPLES OF RECENT HYDRO-ELECTRIC DEVELOPMENTS IN ITALY AND SWITZERLAND.

Schweizerische Bauzeitung.

THE series of articles on Hydro-Electric Power versus Steam, by H. von Schon, which began in THE ENGINEERING MAGAZINE for April last, reaches a most interesting stage elsewhere in this issue. There the distinguished author shows (pages 353-380) three typical modern installations on the American continent—one Canadian, one using the waters of the boundary between the Dominion and the United States, and one belonging to the new industrial South—which by their wide diversity of design demonstrate the great range of adaptiveness of this mode of power generation.

Mr. von Schon's tone, nevertheless, is

that of an advocate for a movement which is yet in its minority in the Western World. The list of undeveloped opportunities which he gives, taken at random from a collection of data many times as great and presented as an appendix to his article, shows that the great things already done are but the beginning of those yet possible in American industrial development. On the Continent of Europe, however, hydro-electric engineering has a longer start. The comparative dearness of fuel and the density of industrial and power-using population combined to turn attention early to the improvement of water powers and to the prompt utilization of every advance in electric generation and transmission. Many of the interesting steps in this progress, as shown by characteristic plants, have been followed by illustrated descriptions in this magazine. Each month, almost, brings fresh examples, and it is of interest to compare some of the most recent with those described or proposed by Mr. von Schon in his current article.

When long-distance electric-transmission lines became an accomplished fact, a great impetus was given to the utilization of waterfalls in Europe, especially in Switzerland and northern Italy where Alpine torrents are numerous and where the demand for power at the manufacturing centers appears to be slowly increasing. One of the streams rising in the Alps and flowing finally into the Gulf of Venice, is the Adige, or as the Germans call it, the Etsch river. Near the city of Verona, a power plant has just been built to supply electrical energy for lights and motors in the vicinity. At a sharp bend in the river near this city the bed is steep and broken by numerous rapids. Just at the beginning of the bend a canal has been built, forming a cut-off about 4900 feet long, diverting part of the water to the power house situated at a point lower down the river. As the river Etsch is subject to great changes of water level, the turbines in the power house are designed for operating under a normal head of 18 feet of water, and at the same time allowance is made for 18 feet variation in the stage of the river. Four turbines, each of 700 horse power, and two of 60 horse power each, are installed, the four main turbines operating the main generators and the two 60 horse-power units driving the direct-current exciters. The turbines were built by Escher, Wyss & Co., of Zurich, and the generators by Brown, Boveri & Co., of Baden. The generators supply three-phase alternating current at 10,000 volts, which is distributed without intermediate transformation to the various centers of distribution. A large textile mill uses about 800 horse power. The energy is stepped down from 10,000 to 500 volts, at which voltage it is distributed to the 69 motors that operate the various machines.

The turbines, with the rotor attached, are massive and set on solid masonry foundations. While as regards capacity, this station is not of unusual size, it is representative of many European plants, which as a rule, are of moderate size as compared with those now commonly built in the United States. Noticeable features in the Etsch installation are the permanent character of the works, the well-designed turbine house, built of stone, and the simple system of distribution. As the power is supplied over only moderate distances, the voltage, 10,000, is as high as is consistent with economy in first cost, and considering the troubles likely to ensue from the use of very high potentials in a damp climate. The regulation of the turbines is said to be excellent; it is accomplished by altering the position of the inlet gates leading to the turbines by means of a set of cylinders containing oil maintained at a pressure of from 70 to 75 pounds per square inch. The station is representative of many now found in Europe, where the available head of water is low, but where, by careful design, a sufficient quantity of water is secured to develop a moderate amount of energy. In this case the available quantity is about 3000 horse power, considered as a minimum the year round through all stages of the river.

In Switzerland every year witnesses some new installation wherein water from the mountain streams, hitherto running to waste, is made to perform some useful work. Recent developments in electric power transmission, pointing the way to the use of high-tension currents over long aerial lines, with the resultant possibilities

of the centralization of power plants with the accompanying use of large power units, are having their effects in recent Swiss installations. A very interesting example of modern practice is found in a station in the northern part of Switzerland, located so as to take advantage of the fall of the river Aare, near Beznau. The Aare, for some distance before it meets the Rhine, flows in a northerly direction, and within a few miles of its mouth, has a fall of about 11 feet. To take advantage of this, a dam was built, and just above a canal was excavated to lead water to the power house situated farther down the river and just beyond a sharp curve. The canal is 3870 feet long, 138 feet wide at the bottom and 200 feet wide at the water surface when filled to a depth of 16 feet. It is constructed on a 15 per cent grade, and delivers the water to a large turbine station, which, in addition, shelters an auxiliary steam plant for use during periods of low water.

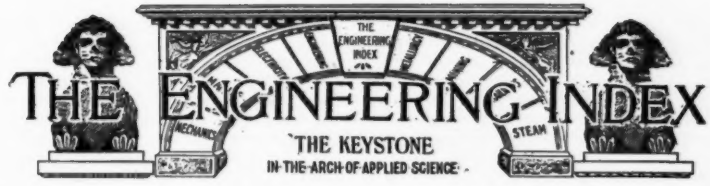
At normal stages of the river, this plant develops 14,000 horse power, which is transmitted by several lines to Zurich, Winterthur, Grüningen, Grynau, Leimbach, Entfelden and Rheinfelden at 25,000 volts, in addition to local circuits near the station to Beznau and vicinity. Most of these transmission lines are from 25 to 65 miles in length, and in the cities and towns just mentioned, the 25,000-volt current is transformed to 8,000 volts for distribution within the town limits.

Eleven turbines are installed at the power house, each rated at 1200 horse power, running at 66⅔ revolutions per minute under 11 feet head of water. In addition to these there are two 400 horse power turbines running at 85 revolutions per minute and driving the direct-current exciter dynamos. Owing to the great variation in the height of water in the river, amounting to about 13 feet, the turbines are built in two parts, the upper and lower being called respectively the high and the low water turbines. The former are built and located in such a manner as to develop the rated power with a large quantity of water under low head, while the low-water wheels pass less water through their blades, but receive it under higher pressure.

Each turbine drives a three-phase alternating-current generator which develops 1200 horse power at 8,000 volts and 50 periods per second. The speed regulation under changes of load is accomplished by a centrifugal governor which controls a valve admitting oil under high pressure to either end of a regulating cylinder, the piston of which imparts motion to rods and levers which move the vanes admitting water to the turbine. It is said that this governor is very sensitive to small changes of load, and holds the speed of the turbine and generator within small limits.

The two exciter machines generate 150-volt direct-current, and either one can take care of all the main generators at one time. There are also installed at this station seven transformers connected on the low-pressure side to the 8000-volt terminals of the generators, and delivering energy to the transmission lines at 27,000 volts. Besides these there are four step-down transformers, 8,000 to 250 volts, to supply local circuits for lights and motors in the station and in its immediate neighborhood.

To avoid any possible interruption of the service from low water or any other cause, an auxiliary steam-driven electric plant has been built which can produce 7,000 horse power, thus furnishing a reserve supply of about 60 per cent., as well as an overload capacity for emergencies. This steam station contains six Dürr watertube boilers, each of 3,767 square feet heating surface and having a superheater which delivers steam at 191 pounds per square inch pressure and superheated 350 degrees C. They are equipped with mechanical stokers and have two steel stacks, 49 feet high, fitted with Sturtevant blowers driven by electric motors. Steam is supplied to two Parsons turbines built by Brown, Boveri and Company, running at 1,500 revolutions per minute and driving the 8,000-volt three-phase generators. Every possible precaution seems to have been taken to insure the continuous operation of this plant and to make use of all power that was available in the immediate vicinity by building the intake canal very long, so as to secure the maximum fall of the river. It is certainly one of the best examples of up-to-date power development in Switzerland, if not in Europe.



The following pages form a descriptive index to the important articles of permanent value published currently in about two hundred of the leading engineering journals of the world—in English, French, German, Dutch, Italian, and Spanish, together with the published transactions of important engineering societies in the principal countries. It will be observed that each index note gives the following essential information about every publication:

(1) The title of each article,
(2) The name of its author,
(3) A descriptive abstract,
(4) Its length in words,
(5) Where published,
(6) When published,

(7) *We supply the articles themselves, if desired.*

The Index is conveniently classified into the larger divisions of engineering science, to the end that the busy engineer, superintendent or works manager may quickly turn to what concerns himself and his special branches of work. By this means it is possible within a few minutes' time each month to learn promptly of every important article, published anywhere in the world, upon the subjects claiming one's special interest.

The full text of every article referred to in the Index, together with all illustrations, can usually be supplied by us. See the "Explanatory Note" at the end, where also the full title of the principal journals indexed are given.

DIVISIONS OF THE ENGINEERING INDEX

CIVIL ENGINEERING 489
ELECTRICAL ENGINEERING 496
INDUSTRIAL ECONOMY 501
MARINE AND NAVAL ENGINEERING..... 502
MECHANICAL ENGINEERING 504
MINING AND METALLURGY..... 512
RAILWAY ENGINEERING 520
STREET AND ELECTRIC RAILWAYS..... 524

CIVIL ENGINEERING

BRIDGES.

Bascule.

The Strauss Trunnion Bascule Bridge Near Rahway, N. J. Illustrated detailed description. 2800 w. Eng Rec—April 13, 1907. No. 83709.

Drawbridge.

A Center-Bearing Drawbridge with Pneumatic Raising Jack and Turning Engine. Translated from *Zeitschrift für Bauwesen.* Illustrated description of an interesting structure recently completed in the city of Hamburg, Germany. 2000 w. Eng News—April 4, 1907. No. 83452.

Maximum Loads.

Maximum Live-Load Bending Moments and Shears for Bridges Carrying Electric Cars. Calls attention to heavy construction cars, service and freight cars, that must at times pass over such bridges and makes a study of the maximum moments. 1500 w. Eng News—April 4, 1907. No. 83449.

We supply copies of these articles. See page 526.

Plate Girder.

Methods and Cost of Constructing a Plate Girder Railway Bridge with Concrete Piers. Illustrated description of a bridge in Oklahoma, with an account of the methods of work and the cost. 2000 w. Engng-Con—April 3, 1907. No. 83-472.

Detailed Cost of Erecting Three Plate Girder Bridges of Ten Spans. Data relating to the cost of erecting three plate girder bridges, on concrete abutments and piers, having pile foundations. 1000 w. Engng-Con—April 17, 1907. No. 83793.

The Warehouse Point Bridge of the New Haven R. R. Illustrated description of an interesting example of plate girder construction for heavy traffic at high speed, with an account of other bridges occupying this site. 1800 w. Eng Rec—April 27, 1907. No. 83945.

Reinforced Concrete.

Concrete Arches with Old Rail Reinforcement. C. L. Slocum. Portion of a paper before the Conn. Soc. of Engrs. Discusses this form of construction, describing the type of arch used for street crossings over the New Haven cut at New Haven, Conn. Ills. 3000 w. Eng News—April 11, 1907. No. 83564.

The Kishwaukee River Bridge of the Elgin & Belvidere Electric Co. Illustrates and describes the construction of a ribbed concrete-steel bridge of four spans. 1300 w. Ry & Eng Rev—April 13, 1907. No. 83728.

The Highway Bridge Near Goshen, Ohio. Illustrated description of a five-span, arched, reinforced concrete bridge, 16 ft. wide and 493.5 ft. long, and its construction. 1600 w. Eng Rec—March 30, 1907. No. 83366.

Reinforced Concrete Structures on the New Austrian State Railways (Der Eisenbetonbau bei den neuen, durch die k. k. Eisenbahnbaudirektion hergestellten Bahnlinien der Oesterreichischen Monarchie). August Nowak. Description of railway and highway bridges and details of their construction. Illus. Serial. Parts II and III. 2200 w. Beton und Eisen—Jan. and Feb., 1907. No. 83601 each F.

Replacement.

Replacement of Bridges and Allied Structures. Herman K. Higgins. Considers the classification, inspection and the determination of when replacement is necessary, and the loads allowable. General discussion. 9000 w. Jour Assn of Engng Socs—March, 1907. No. 83766 C.

Restoration.

The Auld Brig o' Ayr. An interesting account of restoration work to preserve this historic structure in Scotland. Ills. 3000 w. Engng—April 12, 1907. No. 83879 A.

Strengthening.

Strengthening Girder Bridges on the Madras Railway. Edward W. Stoney. Describes methods used in strengthening or renewing a large number of girders with as little interruption to traffic as possible. Ills. 2200 w. Engng—March 29, 1907. No. 83554 A.

Suspension.

The Monongahela River Suspension Bridge at Morgantown, W. Va. W. H. Boughton. A statement of the conditions found on a recent examination of this bridge, especially in regard to the cables. 1000 w. Eng News—April 18, 1907. No. 83894.

The Design of Cable Suspension Bridges with no Guys. (Calcul des Ponts Suspendus à Câble et sans Hauban.) A Paris. Mathematical discussion of a method for estimating the indeterminate stresses. Ill. 2300 w. Bull Tech Suisse Rom—March 25, 1907. No. 83699 D.

Viaducts.

The Sixth Street Viaduct at Kansas City. J. A. Lahmer. Illustrated detailed description of the viaduct extending from Sixth and Bluff streets in Kansas City, Mo., to Fourth street and Minnesota avenue in Kansas City, Kan. 2200 w. R R Gaz—April 12, 1907. No. 83575.

The Reinforced Concrete Viaduct of the Richmond & Chesapeake Bay Railway at Richmond. Illustrated description of a viaduct to carry a single-phase line for freight and passenger service, 2000 w. St Ry Jour—March 30, 1907. No. 83360.

CONSTRUCTION.

Bathhouse.

New Bathhouse of the City of Hanover. (Die neue Städtische Badeanstalt in Hannover.) E. Stack. Description of a large German bathing establishment, with details of construction, heat supply, etc. Ills. 4700 w. Gesundheits Ingenieur—March 2, 1907. No. 83641 D.

Buildings.

Structural Details in the Plaza Hotel, New York. Illustrates and describes interesting details in this 18-story, steel cage hotel, facing Central Park. 2200 w. Eng Rec—March 30, 1907. No. 83371.

Structural Details of the Holy Angels School, Buffalo. An example of reinforced concrete construction combined with brick and stone walls is illustrated and described. 2000 w. Eng Rec—April 20, 1907. No. 83835.

Providence Armory Drill Hall. Illustrates and describes the construction of a 235 x 170 ft. steel drill hall, 70 ft. in extreme height. 1800 w. Eng Rec—April 13, 1907. No. 83711.

We supply copies of these articles. See page 526.

Modern Steel Buildings. John M. Ewen. Read before the School of Prac. Science, Toronto. On modern steel-frame buildings and their construction. 3500 w. Can Archt—April, 1907. Serial. 1st part. No. 83971 C.

Concrete.

Forms for Concrete Construction. Sanford E. Thompson. Read before the Nat. Assn. of Cement Users. Treats of the design, construction and removal of forms. Ills. 3300 w. Sci Am Sup—April 27, 1907. No. 83917.

Concrete Piling.

Artificial Support for Buildings by Means of Concrete Piling. (Künstliche Befestigung des Baubodens mittels Schwebender Pilotage.) Ottokar Stern. Calculations and dimensions for concrete piling. Ills. 2300 w. Beton und Eisen—Jan., 1907. No. 83600 F.

Earth Slip.

The Earth Slip in the Face of the Embankment of the North Dike of the Wachusett Reservoir. Caleb Mills Saville. An account of the slip that occurred on April 11, explaining the conditions. Ills. 800 w. Eng News—April 25, 1907. No. 83911.

The Earth Slide at the North Dyke of the Wachusett Reservoir. A statement of the facts in regard to this slide, with illustrations. 1200 w. Eng Rec—April 27, 1907. No. 83943.

Excavator.

Neukirch Patent Excavating Apparatus (Ueber das Schrämverfahren Patent Neukirch). —— Seyboth. Ills. 5300 w. Glückauf—Feb. 23, 1907. No. 83663 D.

Foundations.

Concrete Pile Foundations for a Tower 700 Feet High. Describes foundation work at Coney Island, N. Y., for a steel structure intended for amusement purposes. Ills. 1600 w. Eng Rec—April 27, 1907. No. 83950.

Framework.

The Steel Framework of a Shop for Light Metal Work. Plan and description of a shop carefully designed to secure minimum weight and avoid interior obstructions, provide for extensive traveling crane service, roof lighting and drainage. 1800 w. Eng Rec—April 27, 1907. No. 83949.

Race Course.

A New Race Course for Parisians. Jean Schopper. An illustrated description of the new Tremblay race-course buildings which embody all the latest improvements. 1200 w. Archt Rec—May, 1907. No. 83929 C.

Reinforced Concrete.

A New Concrete Wood-Worsted Mill. E. S. Larned and Frank E. Warren. Illustrated description of the construction of an important manufacturing plant involving interesting work in reinforced concrete. The work was carried out with speed in freezing weather. 7500 w. Cement Age—April, 1907. No. 83787.

Reinforced Concrete in Power Station Construction. H. L. Knowlton. An illustrated article discussing successful applications of this material, and details of construction. 5500 w. Cassier's Mag—April, 1907. No. 83332 B.

Concrete Reinforcement for Irrigation Structures. F. W. Hanna. Explains some of the differences in the reinforcement for such structures from architectural practice. 1500 w. Eng News—April 4, 1907. No. 83448.

Reinforced Concrete Retaining Wall Design. Evan P. Bone. Explains the theory of design used for the walls, giving table and charts. 5500 w. Eng News—April 25, 1907. No. 83906.

Instructions for Reinforced Concrete Field Work. Extracts from a handbook of instructions prepared by the Engineering Department of the Trussed Concrete Steel Co. of Detroit. 2500 w. Eng Rec—April 6, 1907. No. 83482.

A Code of Instructions for Inspecting and Supervising Reinforced Concrete Construction Work. Extracts from the code of the Trussed Concrete Steel Co., of Detroit, Mich., giving instructions for this work. 6000 w. Engng-Con—April 24, 1907. No. 83922.

Roads.

Road Construction and Maintenance in Johannesburg. G. S. Burt Andrews. Explains the local conditions, the material available, and the work that has been done. General discussion. 9800 w. Jour S African Assn of Engrs—Feb., 1907. No. 83545 F.

Methods of Constructing and Repairing Oiled Roads in California. From the report of N. Ellery, State Highway Commissioner. Gives the plan followed on a good oiled earth highway. 2000 w. Engng-Con—April 24, 1907. No. 83921.

San Francisco.

Some Engineering Lessons of the San Francisco Disaster. J. L. Van Ornum. Especially discussing the fire lessons from this disaster as affecting different engineering materials. 2000 w. Jour Assn of Engng Socs—March, 1907. No. 83767 C.

Reinforced Concrete Construction. Lewis A. Hicks. Information in regard to reconstruction work, especially the use of reinforced concrete. 1400 w. Min & Sci Pr—April 20, 1907. No. 83963.

A Year of Reconstruction. Charles Derleth, Jr. Gives a brief review of the extent of structural damage within the

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earthquake and fire belt, with an outline of the rehabilitation accomplished during the past year. Ills. 5500 w. Min & Sci Pr—April 20, 1907. No. 83962.

The San Francisco of To-day. T. A. Rickard. Illustrations showing the progress of reconstruction, and descriptions of some of the work. 2500 w. Min & Sci Pr—April 20, 1907. No. 83961.

Steam Shovels.

Steam Shovels and Steam Shovel Work in Railway Construction. Discusses the recommendations of the Committee on Roadway of the American Railway Engineering and Maintenance of Way Assn., based on replies to a circular letter of inquiry. 2000 w. Eng News—April 11, 1907. No. 83563.

Structural Steel.

"Common Practice" and Common Defects in Structural Steel Work. Edward Godfrey. Points out some of the absurdities in designs of steel structures, giving examples of actually-observed instances of violations of common principles of mechanics. Ills. 4500 w. Eng News—April 11, 1907. No. 83565.

Theater.

Lincoln Square Theater. F. W. Mayes. Report on the design, construction and arrangement for public safety and fire protection. Ills. 2000 w. Ins Engng—March, 1907. No. 83588 C.

Tunnels.

Pennsylvania Railroad Tunnel Extension Into New York City. A. J. County. Abstract of an address before the Wharton Sch. Assn., Univ. of Penn. Outlines present conditions of transportation around Manhattan, and describes the project for improving the works now under construction by the Pennsylvania R. R. Map. 4200 w. R R Gaz—April 12, 1907. No. 83574.

Progress in Lowering the Tunnels Under the Chicago River. An illustrated report of progress in the lowering of the roofs of two street railway tunnels, and description of methods. 4000 w. Eng Rec—April 13, 1907. No. 83705.

The Tunnels Under the Seine for the Metropolitan Railway at Paris. R. Bonnin. Notes on very interesting work not described in a previous article in the issue of Feb. 15, 1906. Ills. 1200 w. Eng News—April 11, 1907. No. 83567.

The Kicking Horse River Tunnel of the Canadian Pacific Ry. Brief illustrated description of this new tunnel near Palliser, B. C. 1000 w. Eng News—April 18, 1907. No. 83895.

The Great Tunnel. An illustrated article dealing with the construction and use of the Simplon tunnel. 1600 w. Ry & Loc Engng—April, 1907. No. 83528 C.

Warehouses.

The Evolution of the Modern Warehouse. A. O. Elzner. Brief descriptions of old and new structures, especially illustrating a reinforced concrete fireproof building. 2000 w. Archt Rec—May, 1907. No. 83931 C.

The Storage Warehouse of the Fireproof Storage Co., Cleveland, O. Describes the erection of a reinforced concrete building with self-supporting shale-brick walls, 6 stories high. Ills. 1500 w. Eng Rec—March 30, 1907. No. 83368.

MATERIALS OF CONSTRUCTION.

Bricks.

The Story of the Brick. Prof. Edgar J. Banks. Reviews the history of early brick making, and shows how valuable they are in determining the age of ruins. 1200 w. Sci Am—April 6, 1907. No. 83456.

Cements.

Observations on the Testing and Use of Portland and Natural Cements. E. S. Larned. A discussion of tests and of facts from the experience of the writer in the use of this material, with general discussion. 7500 w. Jour N Eng W-Wks Assn—March, 1907. No. 83336 F.

Concrete.

Prevention of Freezing in Concrete by Calcium Chloride. Richard K. Meade. Gives results of a series of experiments made to investigate the effect which calcium chloride exercises in preventing the freezing of mortar. 2200 w. Eng Rec—April 20, 1907. No. 83837.

Concrete Blocks.

The Concrete Block and Its Advance to the Position of a First-Class Building Material. Clarence M. Barber. A discussion of concrete blocks as a building material, their construction, and the advantages claimed. 2200 w. Jour Assn of Engng Socs—March, 1907. No. 83768 C.

Concrete Mixing.

Some Representative Concrete Mixing Plants with Records of Operating Costs. F. W. Daggett. A description of plants, giving a summary of costs both of the installation and operation. Ills. 2000 w. Engng-Con—April 10, 1907. No. 83794.

Hard Woods.

The Hard-Woods of Western Australia. Information from two recent papers on the timbers of Australia, and recent tests made by G. A. Julius. Ills. 2500 w. Engr, Lond—March 22, 1907. No. 83426 A.

Marbles.

The Two Carraras. W. G. FitzGerald. An illustrated article describing the great marble quarries of Italy and of Vermont, the methods of quarrying, loading, etc. 2200 w. Archt Rec—May, 1907. No. 83930 C.

We supply copies of these articles. See page 526.

Piling.

Experience with Steel Sheet Piling in Hard Soils. William G. Fargo. Read at meeting of the Mich. Engng. Soc. Illustrates forms of sheet piling, and describes methods of driving and related matters, giving the cost. 2500 w. Eng News—April 4, 1907. No. 83450.

Reinforced Concrete.

A Theory of the Bending of Straight Reinforced-Concrete Girders (Essai d'une Théorie de la Flexion des Poutres Droites en Béton Armé). M. F. Chaudy. A mathematical discussion giving examples of application to different types of structures. Ill. 8000 w. Mem Soc Ing Civ de France—Feb., 1907. No. 83677 G.

Roofing Tin.

Manufacture of Roofing Tin. Description and illustrations of the process, from the casting of the iron ingots to the rolling of the plates and their immersion in pots containing molten tin and lead. 2000 w. Ins Engng—March, 1907. No. 83589 C.

Sewer Pipe.

Cement Sewer Pipe. Two short papers, by Rudolph Hering, and by Robert W. Lesley, comparing the merits of cement and vitrified clay. 2700 w. Cement Age—April, 1907. No. 83788.

Wood Poles.

Note on the Cost of Preserving Wooden Poles (Beitrag zur Frage der Konservierung hölzerner Leitungsmaste). E. F. Petritsch. Account of various preservatives now used in Europe. 2900 w. Elektrotechnik und Maschinenbau—March 10, 1907. No. 83638 D.

MEASUREMENT.

Anemometer.

Electric Anemometer. R. Goldschmidt. Trans. from *Bul. de la Soc Belge d'Elec.* Illustrates and describes the apparatus. 1000 w. Bul Int Ry Cong—March, 1907. No. 83700 E.

Columns.

Stresses in Simple Columns Under Eccentric Load. O. H. Basquin. A discussion of some of the simple problems on the theory of stresses in columns. 3300 w. Eng News—April 18, 1907. No. 83893.

Leveling Rod.

A Tape Leveling Rod and Its Use. Arthur W. Tidd. Illustrated description of a sliding tape rod by means of which elevations are read off directly. 1200 w. Eng News—April 25, 1907. No. 83907.

Reinforced Concrete.

Diagrams for Proportioning Reinforced Concrete Beams. Gives diagram drawn up by A. H. Perkins, with explanatory notes. 900 w. Eng News—April 25, 1907. No. 83908.

The Use of Tables and Diagrams for Proportioning Reinforced Concrete Members. Editorial warning in regard to the misuse of these aids for conditions to which they are not applicable. 1300 w. Eng News—April 25, 1907. No. 83910.

Retaining Walls.

A Diagram for Overturning Moments on Retaining Walls for Earth or Water. Gives a graphical solution of the Rankine retaining wall formula, which was constructed by Charles H. Hoyt, who has found it a time-saver in retaining-wall work. 700 w. Eng News—April 25, 1907. No. 83909.

Roof Truss.

Calculation of a Two-Hinged Arched Roof Truss (Calcul d'une Ferme en Arc à deux Articulations). E. Aragon. Graphical solution of stresses due to dead and wind loads. Ill. Serial. 1st part. 3500 w. Génie Civil—March 23, 1907. No. 83694 D.

Water Percolation.

New Method of Determining the Direction and Rate of Percolation of Ground Water (Neue Verfahren zur Bestimmung von Richtung und Geschwindigkeit der Grunwasserströmungen). Reinhold Ulfert. Illus. 2300 w. Gesundheits Ingenieure—March 23, 1907. No. 83644 D.

Water Power.

Methods and Results of the Wisconsin Water Power Survey. L. S. Smith. An account of the methods used and cost of this work. 2000 w. Wis Engr—April, 1907. No. 83858 D.

MUNICIPAL.

City Improvements.

Recent Reports on City Plans. Charles Mulford Robinson. Outlines of proposed improvements in St. Paul, St. Louis, Boston and New York. Recommendations for parks, parkways, wider thoroughfares, bridge approaches, etc. Ills. 3000 w. Munic Jour & Engr—April 3, 1907. No. 83437 C.

Garbage.

An 18-Ton Garbage Crematory. Illustrated description of a crematory at Port Ontario, N. Y., designed to destroy 18 tons of the house wastes in 24 hours. 800 w. Eng Rec—April 13, 1907. No. 83707.

Hygiene.

Second International Congress on Hygiene at Geneva, 1906 (Der II Internationale Kongress für Wohnungshygiene in Genf 1906). A. G. Stradal. Abstract of papers read at the convention. Tables. Serial. 2 parts. 7200 w. Zeitschr d Oesterr Ing und Arch Vereins—Feb. 1 and Feb. 8, 1907. No. 83615 each D.

Pavements.

Macadam Streets, Surfaced with California Liquid Asphalt, as Constructed in the City of Redlands, Cal. C. C. Brown. Describes methods found satisfactory on

streets with steep slopes. Ills. 1000 w. Eng News—April 4, 1907. No. 83445.

Roads.

Methods and Cost of Reducing Dust and Hardening Roads by Surface Applications. J. W. Howard. Discusses the treatment of earth, sand, gravel, and macadam roads by surface applications. 5500 w. Engng-Con—April 3, 1907. No. 83473.

The Asphaltic-Oiled and Tamper-Rolled Compressed Dirt Roads of Santa Monica, Cal. Gives specifications for the constructing of oiled dirt roads. Ill. 1300 w. Eng News—April 4, 1907. No. 83446.

Petrolithic Pavement: A New Method of Oiled Road Construction. Illustrated description of this new type of road and the machine with which it is constructed. 1200 w. Engng-Con—April 17, 1907. No. 83795.

Rochester, N. Y.

The Public Works of Rochester, N. Y. Illustrates and describes the new Cobb's Hill reservoir, and the efficient street-lighting system. 2000 w. Munic Engng—April, 1907. No. 83595 C.

Septic Tanks.

The Explosion of the Saratoga Septic Tank. Prof. W. P. Mason. An account of the accident with discussion of the cause. Also general discussion. Ill. 4000 w. Jour N Eng W-Wks Assn—March, 1907. No. 83337 F.

The Septic Tank of the Belleville, Ill., Sewerage System. Plan and sections with description of a tank with a capacity for treating the normal dry weather flow from a system serving a population of 30,000. 1600 w. Eng Rec—April 13, 1907. No. 83710.

Sewage.

The Bacterial Treatment of Sewage, with Special Reference to the Biolysis of Organic Nitrogen. W. D. Scott-Moncrieff. Briefly considers the successive stages in the breaking down of organic matter, especially discussing the third, or nitrifying changes. Diagrams, tables, and discussion. 7800 w. Jour Ry San Inst—April, 1907. No. 83585 B.

Nitrification of Sewage. George Reid. Summary of a paper read before the Ry. Soc. Discusses the construction of filter beds so as to afford the largest possible surface for bacterial growth under healthy conditions. 3000 w. Jour Roy San Inst—April, 1907. No. 83586 B.

The Common Sense of Sewage Pollution. George Ethelbert Walsh. Discusses the proper disposal of municipal sewage. The present article considers the land treatment. 1500 w. Dom Engng—April 6, 1907. Serial. 1st part. No. 83506.

The Sewage Disposal Plant of the Soldiers' Home, Johnson City, Tenn. Describes a plant comprising a septic tank, four contact beds, and four sand filters, designed to operate under a wide variation of flow. 2000 w. Eng Rec—April 27, 1907. No. 83946.

Sewage Disposal Tanks for the Isolated House. Illustrates and describes flush tanks suitable for handling sewage in the process of its disposal. 1800 w. Met Work—April 27, 1907. No. 83932.

Sewage Beds.

An Experience with Clogged Sewage Beds at Pawtucket, R. I. Notes from a bulletin issued by the State Board of Health of Rhode Island in regard to investigations at Pawtucket. 2000 w. Eng Rec—March 30, 1907. No. 83369.

Sewage Filters.

Eight Years' Work with Trickling Sewage Filters at the Lawrence Experiment Station. H. W. Clark. A review of the studies made of such filters at the station named and the results. 5000 w. Eng News—April 11, 1907. No. 83566.

Smoke.

Steps in the Development of a Smokeless City. W. F. M. Goss. Read before the Indiana Acad. of Science. Suggests measures for rendering a city smokeless. 2500 w. Munic Engng—April, 1907. No. 83596 C.

The Smoke Nuisance and Industry (Die Rauchplage und die Industrie). Etienne de Fodor. Various systems of prevention and consumption of smoke discussed. Serial. 2 parts. 9600 w. Elektrotechnik und Maschinenbau—March 3 and March 10, 1907. No. 83637 D.

Stone Crushing.

A Large Stone-Crushing Plant at Gary, Ill. Illustrated description of a new plant having a rated capacity of 300 cu. yds. an hour. 1800 w. Eng Rec—March 30, 1907. No. 83372.

WATER SUPPLY.

Cast-Iron Pipe.

Some Observations on Cast-Iron Pipe Specifications. William R. Conrad. Short paper and general discussion of the New England specifications, and the report of the Committee on Standard Specifications. 7500 w. Jour N Eng W-Wks Assn—March, 1907. No. 83339 F.

Croton Dam.

The New Croton Dam. An illustrated description of the design and construction of this large masonry dam for the additional water supply of New York City. 1700 w. Engr, Lond—April 12, 1907. Serial. 1st part. No. 83885 A.

Fire Protection.

Maintenance Methods and Detailed Costs of Car House Fire Protection in Cleveland. An illustrated account of the

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ways and means of taking care of the extensive sprinkler system installed. 2500 w. St Ry Jour—March 30, 1907. No. 83359.

Hamburger Test.

The Hamburger Test for Pollution (Der Hamburger Test auf Fäulnisfähigkeit). Dr. Korn and Dr. Kammann. Tables. 3900 w. Gesundheits Ingenieur—March 16, 1907. No. 83642 D.

Irrigation.

Millions for Moisture. C. J. Blanchard. An illustrated account of the work of the United States reclamation service. 6400 w. Nat Geog Mag—April, 1907. No. 83853 C.

The Government Irrigation Project at Roosevelt Dam, Salt River, Arizona. Prof. Oscar C. S. Carter. Remarks on the irrigation of this region before the Government took the matter in charge, with information of the projects since carried out or under construction, especially the Roosevelt dam. Ills. 7500 w. Jour Fr Inst—April, 1907. No. 83758 D.

Meters.

Meter Registration. Arthur N. French. An account of a water meter which registered when no water was passing through the pipes, explaining the cause and remedy. General discussion. 6800 w. Jour N Eng W-Wks Assn—March, 1907. No. 83338 F.

Montreal.

Montreal's Water Supply. An account of proposed improvements with the estimated cost. 1700 w. Can Engr—April 5, 1907. No. 83504.

Oregon.

The Water Supply of the Oregon Short Line at Pocatello, Idaho. Describes an extensive system supplying division shops and furnishing water for general railroad use. Illustrates details. 2000 w. Eng Rec—April 27, 1907. No. 83944.

Purification.

The Cincinnati Water Purification Plant. E. G. Monahan, and J. W. Ellms. Illustrated description of the plant and method of operation, reviewing the past history of the water supply, and giving costs. 7000 w. Eng Rec—April 6, 1907. No. 83479.

See Railway Engineering, Motive Power and Equipment.

Supply.

The Struggle for Water in the Great Cities of the United States. Marsden Manson. Presents certain features of the great problems of municipal water supply. Considers ownership, and those requiring change of source or expensive treatment. New York and San Francisco are taken as examples. 8000 w. Jour Assn of Engng Socs—March, 1907. No. 83765 C.

WATERWAYS AND HARBORS.

Barge Canal.

The Section of the Barge Canal Connecting the Hudson and Mohawk Rivers. H. P. Willis. Brief illustrated account of the interesting work on this section. 600 w. Eng Rec—March 30, 1907. No. 83373.

The New York Barge Canal Improvements. William G. Landreth. Gives map and profile for the barge canal now being built, describing the location of locks and dams and other features of the work. 2200 w. Eng Rec—April 13, 1907. No. 83708.

Canada.

The Canadian Waterway to the Atlantic. H. K. Wicksteed. An address before the Canadian Club, Montreal. An explanation of the project with description of the route. 4500 w. Can Engr—April 5, 1907. No. 83503.

Docks.

Difficult Underpinning and Dock Work in Chicago. Illustrates and describes some complicated dock and underpinning work in connection with the increase in the width of the Chicago River. 1800 w. Eng Rec—April 20, 1907. No. 83833.

Dredges.

Dredges (Les Dragues). A. Baril. The first instalment of this article deals with bucket dredges, outlines their history, describes various types and operations and gives details of capacity, etc., under different conditions of work. Ill. Serial. 1st part. 7000 w. Rev de Méch—March 31, 1907. No. 83681 E + F.

Electric Haulage.

Electric Haulage of Boats (Halage Electrique des Bateaux). Léon Gerard. Results of experiments on electric haulage on canals carried out by the General Electric Company in 1905, description of tractor, etc. Ill. 3300 w. L'Alliance Industrielle—April, 1907. No. 83685 D.

Harbors.

Notes on Harbor Engineering. J. R. Baterden. A discussion of the effects of wave action, and other matters relating to structures in the sea. 3000 w. Engr, Lond—April 5, 1907. No. 83749 A.

The Harbor Improvements at Salina Cruz, Mexico. Illustrated notes on the terminal facilities of the Pacific terminus of the Tehuantepec National Railroad. 1300 w. Eng Rec—March 30, 1907. No. 83365.

The Entrance to the Mersey. An account of improvements to be made at the Port of Liverpool for the safety and convenience of ships. 2200 w. Engng—March 15, 1907. Serial. 1st part. No. 83465 A.

Inland Waterway.

The North Carolina-Virginia Inland Waterway. H. L. Wilson. Illustrates and

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describes this project, the two routes under consideration, and states the advantages of having a complete inland passage from Chesapeake Bay to and through Beaufort Inlet. Map. 1300 w. Sci Am—April 13, 1907. No. 83576.

Lift Locks.

The Kirkfield Hydraulic Lift Lock. Illustrated description of this recently completed lock on the Trent Canal, Ontario, and its operation. 2000 w. Eng Rec—March 30, 1907. No. 83370.

Piston Lifts for Ships (Ueber Kolbenhebewerke für Schiffe). Artur Budau. Description of caisson lifts used on canals. Illus. Serial. 2 parts. 5600 w. Zeitschr d Oesterr Ing u Arch Vereins—Feb. 1 and Feb. 8, 1907. No. 83614 each D.

Missouri.

Improvement Work on the Missouri River (Travaux d'Amélioration du Missouri). F. Marchais. A summary of the methods which have been tried to improve navigation on the Missouri and the work now in hand. Ill. 4000 w. Génie Civil—April 6, 1907. No. 83683 D.

Panama.

The Present Status of the Panama Canal. An account of what has been accomplished, and the work in progress, the most pressing need at the Colon terminus of a system of breakwaters to provide a safe harbor. 3800 w. Engng—March 15, 1907. No. 83467 A.

Paraná.

Ship Canal from Buenos Ayres to the Paraná de Las Palmas (Canal Marítimo de Buenos Aires al Paraná de Las Palmas). Julio B. Figuerva. The first part of the serial outlines the nature of the project and discusses the problems to be solved. Ill. Serial. 1st part. 4500 w. La Ingenieria—Jan. 30, 1907. No. 83995 D.

Rhine.

Rectification of the Rhine and the Cut at Diepoldsau (Die Rheinkorrektion und der Diepoldsauer Durchstich). Detailed description of improvement works on the lower stretches of the Rhine. Illus. Serial. 3 parts. 5800 w. Schweizerische Bauzeitung—Jan. 5, Jan. 12, and Jan. 19, 1907. No. 83619 each B.

Rosario.

Fascine Protection Works at the Port of Rosario (Puerto del Rosario: Obras de Faginado). Domingo Carrique. Illustrated description of the method used for protecting the shore by means of fascines. 2000 w. La Ingenieria—Feb. 15, 1907. No. 83672 D.

Teltow.

The Teltow Canal (Verein für Eisenbahnkunde zu Berlin—Ueber den Teltowkanal). Havestadt. Paper presented to the Berlin Railway Club; a complete account of the canal. Illus. 5600 w. Glasers Annalen—March 15, 1907. No. 83624 D.

The Electrical Equipment of the Teltow Canal. Brief illustrated description. 1500 w. Elec Rev, Lond—April 19, 1907. No. 83991 A.

ELECTRICAL ENGINEERING

COMMUNICATION.

Arcophone.

How to Construct a Speaking Arc. A. Frederick Collins. Description and diagrams with explanation of the theory and of some of the applications. 2000 w. Sci Am Sup—April 27, 1907. No. 83915.

Radio-Telegraphy.

Arrangement of Wireless Telegraph Apparatus. D. McNicol. Gives a diagram and description of an arrangement explaining its merits. 700 w. Elec Wld—April 6, 1907. No. 83496.

Telegraphy.

The Baudot Telegraph System in India. C. T. Williams. Brief description of this system and its working in India. Ills. 3000 w. Elect'n, Lond—March 22, 1907. No. 83418 A.

Experimental Study of Telegraph Lines and Apparatus (Etude Expérimentale des Lignes et des Appareils Télégraphique). M. Devaux-Charbonnel. Researches on the resistance and insulation, capacity, self-inductance, etc., of telegraph lines. Mathematical discussion. Ill. 9000 w. Bull d l Soc Inter d'Elec'ns—Mar., 1907. No. 83696 F.

Telephony.

Aspects of Recent Telephone Development. Howard S. Knowlton. Remarks on the remarkable increase in telephone traffic and an explanation of why the telephone message should be considered the unit. 2500 w. Elec Wld—Mar. 30, 1907. No. 83352.

Notes on the Development of Telephone Service. Fred De Land. Considers the forms of transmitters and the development of the wall telephone, and related subjects. Ills. 3000 w. Pop Sci M—May, 1907. No. 83920 C.

The Telephone Repeater. Louis Cohen. Discusses the requirements of a telephonic repeater, explaining how it differs

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from a telegraphic repeater. 800 w. Elec Wld—April 6, 1907. No. 83499.

Induction on Telephone Lines (Inductie verschiznselen op telefoonlijnen). A. A. Oosting. Outline of several methods of avoiding inductive disturbances on telephone circuits. Illus. 5900 w. De Ingenieur—Mar. 2, 1907. No. 83656 D.

DYNAMOS AND MOTORS.

Brushes.

Brush Holders and Brushes for 500-Volt Motors. Eugene C. Parham. Considers troubles incident to abuse, neglect, poor design, or bad condition of the commutator. 1500 w. Elec Wld—April 6, 1907. Serial. 1st part. No. 83501.

Brushholders.

Some Brushholder Experiences. Henry Schlegel. Discusses what may be expected where brushholders are neglected or are maintained by incompetent labor unaided by the necessary jigs and gages. 3500 w. St Ry Jour—April 13, 1907. No. 83704.

Circulating Currents.

Circulating Currents in Three-Phase Generators. A. G. Grier. Explains the limitations of the wave form in the three-phase system, giving an analysis of the wave forms of a three-phase star-connected generator in which circulating currents were known to exist when connected in delta. Diagrams and tables. 2000 w. Elec Jour—April, 1907. No. 83582.

D. C. Dynamos.

Unstable Conditions in the Operation of Direct Current Machines (Unstabile Betriebszustände bei Gleichstrom Maschinen). Karl Willy Wagner. Mathematical discussion. 2000 w. Elektrotechnische Zeitschrift—March 28, 1907. No. 83652 B.

Induction Motors.

A New Type of Induction Motor. Louis J. Hunt. Read before the Manchester Soc. of the Inst. of Elec. Engrs. Illustrates and describes a motor possessing all the characteristics of the ordinary type of slip-ring induction motor, but differing from it in the arrangement of the windings. 3500 w. Mech Engr—April 13, 1907. No. 83869 A.

Calculation of the Leakage-Reactance of Induction Motors. J. E. Hanssen. Presents, in a condensed form, the formulae contained in Prof. Adams' papers, which in practice have proved to be accurate and convenient. 1000 w. Elec Wld—March 30, 1907. No. 83351.

Zig-zag Leakage of Induction Motors. R. E. Hellmund. A study of the values of zig-zag leakage. Diagrams. 3000 w. Pro Am Inst of Elec Engrs—March, 1907. No. 83764 D.

Winding Diagrams.

Continuous-Current Armature Winding Diagrams. H. M. Hobart. An explanation of the practice of diagrammatically representing windings of armatures. Ills. 2500 w. Elec Rev, N Y—March 30, 1907. Serial. 1st part. No. 83348.

DISTRIBUTION.

Switch Indicator.

A New End-Cell Switch Indicator. A. A. Radtke. Illustrated description of a new form of end-cell switch indicator designed to replace the telephone drop type. 800 w. Elec Wld—April 13, 1907. No. 83717.

Systems.

Electric Distribution Systems. Prof. A. H. Ford. Extract from a paper read before the Iowa Elec. Assn. Discusses the selection and design of a system from the standpoint of cost and operating characteristics. 2000 w. Elec Wld—April 27, 1907. No. 83976.

Three-Phase.

Three-Phase Four-Wire Distribution. H. L. Wallau. Shows the high transmission efficiency and economy of this system. Diagrams. 2000 w. Elec Age—April, 1907. No. 83956 C.

Wiring.

Bell and Telephone Work in Fireproof Buildings. T. W. Poppe. Suggestions for wiring. Ills. 900 w. Elec Wld—April 6, 1907. No. 83498.

ELECTRO-CHEMISTRY.

Bleaching.

Electric Bleaching (Zum Kapitel: Elektrische Bleiche). V. Engelhardt. Abstract discussion of the subject. 2400 w. Electrochem Zeitschr—March, 1907. No. 83670 G.

The Problems of Bleaching with Paper-Pulp Electrolytic Hypochlorite Solutions. W. Pollard Digby. Notes on investigations made by the writer which lead him to believe very strongly in the possibilities of electrolytic hypochlorite processes for paper and textile bleaching. 4500 w. Elec-Chem & Met Ind—May, 1907. No. 83979 C.

Calcium.

Critical Review of the Electrolytic Production of Calcium (Kritische Betrachtungen Ueber Die Elektrolytische Gewinnung Des Calcums). Carl Bürgel. Detailed description of processes. Continuation of serial. Illus. 2100 w. Elektrochem Zeitschr—March, 1907. No. 83671 G.

Electric Furnaces.

New and Unique Electric Furnaces Without Electrodes. Frank C. Perkins. An illustrated description of the Hiorth induction electric furnace. 900 w. Min Rept—March 28, 1907. No. 83377.

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Old and New Patterns of Electric Furnaces (Ueber elektrische Ofen älterer und neuer Systeme). Gustav A. Pummer. Descriptive article, treating of various types that have been tried. Illus. Serial. 2 parts. 3200 w. Oesterr Zeitschr f Berg und Hüttenwesen—March 2 and 9, 1907. No. 83636 each D.

Electrolysis.

Soil Electrolysis with Formation of a Liquid Sodium Potassium Alloy. Henry Bassett, Jr. Describes a case showing the magnitude of the chemical processes which may be caused by such earth currents. 3000 w. Elect'n, Lond—April 12, 1907. No. 83876 A.

Electroplating.

The Electroplating of Plaster of Paris Objects. Illustrates and describes the process of coating works of art with metal. 4800 w. Brass Wld—April, 1907. No. 83928.

Films.

The Capacity and Resistance of Aluminium Anode Films. C. McCheyne Gordon. Abstracted from the *Phys. Rev.* A study of these films, describing investigations. 2500 w. Elect'n, Lond—March 22, 1907. No. 83419 A.

Glocken Process.

The Aussig Glocken Process for Alkali Chloride Electrolysis. Dr. Otto Steiner. An explanation of the process, stating its advantages and disadvantages. 2000 w. Elec-Chem Met Ind—May, 1907. No. 83977 C.

ELECTRO-PHYSICS.

Arresters.

Multi-Gap Lightning Arresters with Ground Shields. R. B. Ingram. Calls attention to phenomena in the operation of lightning arresters of the multi-gap type regarding the effect of variation in the relative position of the multi-gaps and the ground and the distance between them, and explains the use of the ground shield as a remedy. 1700 w. Elec Jour—April, 1907. No. 83583.

Electric Waves.

Electric Wave Propagation. J. E. Taylor. Read before the Inst. of P. O. Elec. Engrs. The paper aims to give mental pictures of the actions and processes underlying electric wave propagation. Diagrams. 3500 w. Elec Rev, Lond—April 19, 1907. Serial. 1st part. No. 83992 A.

Induction Coils.

The Making of Small Induction Coils with Bare Wire. A. Frederick Collins. Describes a method of winding with bare wire on the primary helix instead of using insulated wire. Ills. 1500 w. Sci Am Sup—April 13, 1907. No. 83580.

Insulation.

The Insulation of Electrical Appliances. O. J. Williams. Abstract of a paper read before the Newcastle Loc. Sec. of Inst. of Elec. Engrs. Reviews the elementary phenomena of dielectrics, and explains to some extent the scientific basis on which effective insulation depends. 1500 w. Elecn'n, Lond—April 12, 1907. No. 83875 A.

Magnetic Detector.

The Construction of a Magnetic Detector. Edward G. Gage. Gives directions for making a home-made detector, with brief notes on early researches. Ills. 2000 w. Sci Am—April 6, 1907. No. 83457.

Resistivity.

The Resistivity-Temperature Coefficient of Metals. Harold Pender. The object of the note is to put into convenient form for easy calculation the ordinary formula for the change in the resistivity of copper with the change in temperature. 300 w. Elec Wld—April 13, 1907. No. 83719.

GENERATING STATIONS.

Beznau.

Electric Power Station at Beznau on the Aar (Elektrizitätswerk Beznau an der Aare Anlage für die Erzeugung elektrischer Energie). Comprehensive description of a large combined hydraulic and steam plant in Switzerland. Illus. Serial. 7 parts. 10000 w. Schweizerische Bauzeitung—Feb. 9, 16 and 23, March 2, 16, 23 and 30, 1907. No. 83632 each B.

Card Records.

Notes on a Central Station Card Record System. George W. Martin. Describes the manner in which the United Electric Light and Power Company, of New York, keeps track of its customers and the apparatus used by them. 2000 w. Elec Wld—April 6, 1907. No. 83494.

Frequency.

Frequency Changers. J. P. Jollyman. Considers some of the operating features of 60 to 25, or 25 to 60 cycle synchronous frequency changers. 1200 w. Elec Wld—April 6, 1907. No. 83500.

Hungary.

Electric Power Plants in Austro-Hungary (Die Starkstrom-Industrie in Oesterreich-Ungarn). Emil Honigmann. Enumeration of all the important Hungarian plants, with tables giving particulars of kind of prime mover employed, kilowatts capacity, kind of service furnished, etc. Serial. 2 parts. 5200 w. Elektrotechnische Zeitschrift—March 7 and 14, 1907. No. 83648 each B.

Hydro-Electric.

Overcoming Loss of Head from Flooding. Enrico Bignami. An account of experiments at Chevres, near Geneva, for utilizing the unused kinetic energy wasted because of the flood to return to the sta-

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tion part of the energy lost on account of the loss in head. 1500 w. Engr, U S A —April 1, 1907. No. 83386 C.

The Hydro-Electric and Water Power Plant of a Large Paper Mill. Illustrates and describes a recently completed large pulp and paper mill in Minnesota on the Mississippi River, especially its power equipment. 3500 w. Eng Rec—April 6, 1907. No. 83481.

The Central Station of the Albula (La Centrale Elettrica dell' Albula). Details of this new station for the supply of electrical energy to the city of Zurich. 3000 w. L'Elettricita—March 1, 1907. No. 83678 D.

The Sill Power Plant near Innsbruck (Die Sillwerke bei Innsbruck). Comprehensive description of a large hydro-electric plant in Tyrol, Austria. Illus. Serial. 2 parts. Elektrotechnik und Maschinenbau—March 24 and 31, 1907. No. 83640 each D.

London.

The Electrical Power Supply of London. C. S. Vesey-Brown. Explains the difficulties encountered, giving a brief review of the establishment of electrical supply as far as it concerns London, proper, and discussing proposed schemes. 6000 w. Cassier's Mag—April, 1907. No. 83333 B.

Municipal Plant.

A Successful Municipal Lighting and Power Plant. Describes the plant at South Norwalk, Conn., giving an account of its history, development and growth. Ills. 2500 w. Elec Wld—April 6, 1907. No. 83493.

Power Plants.

The Design of a 1500 to 3000-kilowatt Steam-Electric Central Light and Power Plant. Frank Koester. Brief discussion of the questions involved in the design of a small plant. Ills. 4000 w. Elec Rev, N Y—April 20, 1907. Serial. 1st part. No. 83839.

The Central Power Station at the Plant of Walter Baker & Co., Ltd. Illustrated description of a plant for supplying power for a group of buildings, showing the economy of electric distribution. 3000 w. Eng Rec—April 20, 1907. No. 83836.

Potomac Electric Power Company's New Plant. C. H. Claudy. Illustrated description of a large steam-turbine station of interesting design, concrete-block construction, erected at Washington, D. C. 2500 w. Power—May, 1907. No. 83860 C.

A Small Central Station in Nebraska. Jas. A. Ward. Illustrated detailed description of an electric light plant for a place of about 1000 inhabitants. 2500 w. Elec Wld—March 30, 1907. No. 83350.

The Central Station for Heating, Light, and Power at Glen Eyrie. Konrad Meier. Plan and description of the plant on a country estate near Colorado Springs, Colo. 5500 w. Eng Rec—April 27, 1907. No. 83941.

Regulators.

Induction Potential Regulators. W. T. Fernandez. Describes a type of transformer used in conjunction with polyphase rotary converter systems for the purpose of providing a method of variable control of the secondary voltage on the alternating-current side of the machines. 1600 w. Elec Wld—April 6, 1907. No. 83497.

Switch-Gear.

Extra-High-Tension Switch-Gear. Introductory remarks on the rapid evolution of switch-gear, with an illustrated description of the gear recently constructed for the St. Andrew's Cross Station of the Glasgow Corporation. Plate. 3000 w. Engng—March 29, 1907. Serial. 1st part. No. 83553 A.

Turbo-Alternators.

Two-Pole Turbo-Alternator with Stationary Field and Magnetically-Shunted Exciter. A. Hegland. Discusses means of reducing the capital cost of such machines, with special reference to two-pole machines. 3500 w. Elect'n, Lond—April 12, 1907. No. 83872 A.

Water Power.

The Cataract of Iguazu. Henry Harley. Illustrates several cataracts of South America capable of developing vast power, especially describing the cataract named on the Upper Parana. 2000 w. Cassier's Mag—April, 1907. No. 83330 B.

LIGHTING.

Arc Lamps.

Recent Progress in Arc Lamps: Flaming Arcs (Les Progrés Récents des Lampes à Arcs: les Arcs à Flamme). M. Blondel. A thorough discussion of this class of arc lamp, descriptions of different types, their construction, operation and principles. Serial. 1st part. Ill. 10500 w. Bull d l Soc Inter d'Elec'ns—March, 1907. No. 83697 F.

Costs.

Comparative Costs of Gas and Electric Lighting. E. G. Hennard. Read before the Students' Sec. of the Inst. of Elec. Engrs. Gives a brief study of the prices of gas and electricity in London, and a general consideration of lighting costs, with explanation of methods used. 2300 w. Elec Engr, Lond—April 19, 1907. Serial. 1st part. No. 83989 A.

Frosted Lamps.

An Analysis of the Causes of Candle-

Power Diminution in Frosted Lamps. Preston S. Millar. Discusses the nature of the causes of rapid depreciation of lighting with frosted lamps. Also editorial. 3000 w. Elec Wld—April 20, 1907. No. 83852.

An Explanation of the Short Life of Frosted Lamps. Edward P. Hyde. An explanation of the rapid decrease in candle-power of frosted lamps. 1500 w. Elec Rev, N Y—April 6, 1907. No. 83485.

Illumination.

The Relative Efficiency of Light Sources. E. Percival Lewis. Explains the nature of the problem of illumination and suggests the direction in which progress may be expected, describing some recent improvements in methods of lighting. 2500 w. Cal Jour of Tech—April, 1907. No. 83954.

Comparison of Methods of Office Illumination. Edward A. Norman. Abstracted from a paper before the Ill. Engng. Soc. Shows results obtained by three different methods of office illumination, comparing the relative efficiencies, and presents results secured by arc lamps of the concentric diffuser type in a drafting room. Ills. 2000 w. Elec Rev, N Y—April 27, 1907. No. 83951.

Lamps.

The Effect of High Efficiency Lamps on the Electric Lighting Industry. W. Tatlow. Read before the Dublin Loc. Sec. of the Inst. of Elec. Engrs. Discusses the effect of the new lamps on the design of a private installation, showing how low voltage lamps may be used without the necessity of a transformer to transform the whole current required. 2000 w. Elect'n, Lond—April 12, 1907. No. 83874 A.

The Small Station and the New Lamps. Harry V. Forest. Discusses the changes anticipated in the electric lighting business from the introduction of high efficiency lamps, giving suggestions. 1500 w. Elec Wld—April 6, 1907. No. 83495.

Train Lighting.

The Verity-Dalziel System of Train Lighting. Illustrated description. 1200 w. Elec Rev, Lond—March 29, 1907. No. 83547 A.

Tungsten.

The Tungsten Lamp (La Lampe au Tungstène). A. Bainville. Details of their manufacture and utility showing curves of lighting power. Ill. 1200 w. L'Elec'n—March 23, 1907. No. 83687 D.

Vacuum-Tube.

The Moore Vacuum-Tube Light and the Luminosity of Gases. C. J. Thatcher. A brief description of this lamp and a consideration of its salient features, and its possible bearing on gaseous luminosity. 3200 w. Elec-Chem & Met Ind—May, 1907. No. 83980 C.

MEASUREMENT.

Candle Power.

Measurement of the Instantaneous Candle Power of Alternating Current Lamps. (Messung der Momentanwerte der Lichtstärken von Wechselstromlampen). Johann Sahulka. Illus. 2600 w. Elektrotechnik und Maschinenbau—March 17, 1907. No. 83639 D.

Core Losses.

Eddy Current Losses in Armature Teeth. F. E. Meurer. Develops a method by which the core losses in dynamo-electric machinery may be determined with the aid of only a small amount of empirical approximation. 3000 w. Elec Wld—April 20, 1907. No. 83850.

Gauge.

Frahm's Speed and Frequency Gauge. Frederick Lux. Gives an explanation of resonance and an illustrated description of the Frahm resonance speed gauge and its use. 4500 w. Bul Int Ry Cong—March, 1907. No. 83599 E.

Insulation.

Measurement of Wire and Cable Insulation. Tracy D. Waring. An article suggested by a recent paper by F. Wachter giving a summary of the sources of error met with in the measurement of cable insulation resistances. 2500 w. Elec Wld—April 20, 1907. No. 83851.

Iron Testing.

The Testing of Iron Electrically and Magnetically for Commercial Purposes. P. R. Fortin. Abstract of a paper read before the Northampton Inst. Engng. Soc. Describes the equipment and routine of a works laboratory, especially the tests for permeability and for energy losses. 1600 w. Elec Engr, Lond—March 22, 1907. No. 83417 A.

Losses.

The Experimental Determination of the Losses in Motors. Charles F. Smith. Read before the Manchester Sec. of the Inst. of Elec. Engrs. The present number deals with direct-current motors, and the methods of separating the losses, giving tests. 3000 w. Mech Engr—April 20, 1907. Serial. 1st part. No. 83988 A.

Ondameter.

The Ondameter or Electric Wave Meter. Illustrated description of the construction and operation. 1000 w. Sci Am Sup—April 6, 1907. No. 83463.

Testing.

Rules Concerning the Acceptance and Testing of Electric Machines, Transformers and Apparatus (Régles Concernant la Réception et les Essais des Machines, Transformateurs et Appareils Electriques). Regulations of the Milan As-

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sociation of Users of Electrical Energy. 2800 w. L'Elec'n—March 23, 1907. No. 83688 D.

Watt.

What is a Watt? George Sherwood Hodgins. An explanation of this electrical term. 1400 w. Ry & Loc Engng—April, 1907. No. 83532 C.

Wattmeter.

Siemens & Halske Improved Wattmeter (Das Drehstrom Wattmeter der Siemens & Halske, A. G.; und eine Neukonstruktion ihres Präzisions-Wattmeters). Hilmar Sack. Detailed description of the instruments and calculation of their limits of accuracy. Illus. 2000 w. Elektrotechnische Zeitschrift—March 21, 1907. No. 83650 B.

TRANSMISSION.

Alternating Currents.

Drop in Alternating-Current Circuits. Charles F. Scott and Clarence P. Fowler. Describes a modification of the usual method of finding the drop. Tables and diagrams. 1200 w. Elec Jour—April, 1907. No. 83584.

Cables.

Some Notes on Underground Mains. W. M. Rogerson. Abstract of a paper read before the Leeds Loc. Sec. of the Inst. of Elec. Engrs. Briefly describes the various methods of laying cables underground and the maintenance of mains, giving the author's experiences. 4500 w. Elect'n, Lond—April 5, 1907. No. 83740 A.

The Depreciation of Underground Cables. F. Fernie. Discusses the different single cable systems and their relative advantages as regards depreciation. 3300 w. Elec Rev, Lond—April 5, 1907. No. 83739 A.

High Tension.

Pressure Rise on High-Tension Transmission Lines. E. Hudson. Read before the Dick-Kerr Engng Soc. Discusses the direct causes of pressure rise. 2000 w. Elec Engr, Lond—March 22, 1907. No. 83416 A.

Insulation.

Rubber Insulation. William A. Del Mar. Briefly discusses the adulteration, vulcanization, and quality of rubber, and other matters determining its suitability for insulating uses. 3000 w. Elec Age—April, 1907. No. 83955 C.

Leakage.

The Localization of Earth Leakages on a Three-Wire Network. W. A. Toppin. Discusses systems for the actual location of the leakages, giving diagrams. 2000 w. Elec Engr, Lond—April 12, 1907. No. 83870 A.

Lightning.

Lightning Phenomena in Electric Circuits. Charles P. Steinmetz. Explains the most general meaning of lightning, discussing in detail the phenomena of abnormal voltage and frequency in electric circuits, showing how vast is the problem. Diagrams. 5000 w. Pro Am Inst of Elec Engrs—March, 1907. No. 83763 D.

INDUSTRIAL ECONOMY

Accounting.

A System of Coal-Mine Accounting. F. A. Hill. Explains a system evolved by the writer which has proved satisfactory in use. 1300 w. Eng & Min Jour—March 30, 1907. No. 83357.

Chemistry.

The Methods and the Importance of the System of Organic Chemistry (Die Methoden und die Bedeutung der organisch-chemischen Technik). Otto N. Witt. Discussion of the commercial importance of organic chemistry. 5100 w. Zeitschr d Oesterr Ing u Arch Vereines—March 15, 1907. No. 83654 D.

The Interrelation of Chemistry and Engineering in Technology (Das Zusammenwirken von Chemie und Ingenieurwesen in der Technik). George Lunge. Serial. 3 parts. 8200 w. Zeitschr d Oesterr Ing u Arch Vereines—Feb. 15, Feb. 22, and March 1, 1907. No. 83617 each D.

Chile.

The Mining Industry in Chile. Henry C. Ede. Information in regard to Chile as a copper and silver producer. 2500 w. Min Jour—March 23, 1907. No. 83420 A.

Cost-Keeping.

Cost-Keeping in the U. S. Reclamation Service. A statement concerning the character of the information which it is desired to obtain, with extracts from the Manual of Field Accounting showing how the methods can be adapted to obtain the results. 3800 w. Eng News—April 25, 1907. No. 83905.

Expense: Manufacturing and Commercial. F. E. Webner. The eighth of a series of articles on cost-keeping. 2200 w. Ir Trd Rev—April 4, 1907. No. 83475.

Jobbing Foundry Cost System. H. D. Miles. Explains a simple and comprehensive system recommended by the Jobbing Founders' Assn. 1400 w. Foundry—April, 1907. No. 83591.

Cost-Systems.

Cost Reduction Through Cost Comparison. C. E. Knoeppel. Third and con-

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cluding paper of a series. The present number considers the organization and functions of a cost-reducing department. 4000 w. Engineering Magazine—May, 1907. No. 83940 B.

Exhibition.

Building Trades Exhibition. Describes the principal exhibits at this show at Olympia. 2000 w. Engr, Lond—April 12, 1907. Serial. 1st part. No. 83887 A.

Germany.

The German Engineering Industry in 1906. A review of this past year, which on the whole, was the best since 1900. 1500 w. Engr, Lond—March 22, 1907. No. 83425 A.

Iron Trade.

The Royal Canal Commission and the Iron Trade. Evidence submitted by J. Stephen Jeans for the British Iron Trade Association, before the Royal Canal Commission. 4000 w. Ir & Coal Trds Rev—March 22, 1907. Serial. 1st part. No. 83432 A.

Laboratory.

The New Testing Laboratory at Charlottenburg. Describes this new laboratory at Gross-Litcherfelde, illustrating many of the testing machines employed in testing materials to be used for scientific and commercial purposes. 2800 w. Engr, Lond—March 29, 1907. No. 83552 A.

Municipal Ownership.

The New Orientation of the Municipal Administrations (L'Orientation Nouvelle des Régies Communales). Ernest Brees. Review of Municipal Ownership in Europe and the new system of concession with profit-sharing, its advantages and disadvantages. 12600 w. Rev Econ Inter—March, 1907. No. 83692 E + F.

Oil Industry.

The Future of the Oil Industry in California. Edmond O'Neill. Outlines the past history, and briefly considers the changed conditions, and the problems of transportation, markets for the oil, and related matters. Considers the future outlook bright. 1500 w. Cal Jour of Tech—April, 1907. No. 83953.

Packing.

The Packing of Machinery for Export. W. E. Partridge. An illustrated article describing methods employed successfully in shipping over long routes self-contained machines weighing from 500 to 1500 pounds. 2000 w. Cassier's Mag—April, 1907. No. 83335 B.

Shop Stores.

A Theory of Stores Operation for Machine Shops. H. L. Whittemore. A valuable contribution to the subject of stores keeping, explaining a method which proved useful in a large manufacturing business. 5000 w. Engineering Magazine—May, 1907. No. 83939 B.

MARINE AND NAVAL ENGINEERING

Cable Steamer.

New Japanese Cable Steamer. Particulars of the "Ogasarara Maru," built in Japan. Ills. 2500 w. Elect'n, Lond—April 12, 1907. No. 83873 A.

Cargo Steamers.

The Evolution of the Modern Cargo Steamer. S. J. P. Thearle. Read before the Inst. of Naval Archts. Reviews the development of the modern ocean cargo steamer during the past forty years. The present article discusses the external form and outline, decks, etc. 5800 w. Int Marine Engng—May, 1907. Serial. 1st part. No. 83898 C.

Special Types of Hull Construction for Cargo Steamers. Gives illustrated descriptions of types built in England, showing progress. 2000 w. Eng News—April 4, 1907. No. 83447.

Corrosion.

Corrosion of Steel Boiler Tubes on Vessels Fitted with Turbine Engines. J. Edward Palmer. An account of an interesting case of unusual corrosion caused by copper carried from the bronze turbine blades, by the steam. 800 w. Jour Am Soc of Nav Engrs—Feb, 1907. No. 83770 H.

Cruiser.

Launch of H. M. S. Indomitable. Illustration, account of the launch, and information of this first of three vessels of the same class for the British Navy. 1700 w. Engr, Lond—March 22, 1907. No. 83429 A.

Diesel Motor.

The Diesel Engine for Ship Propulsion (Der. Diesel Motor als Schiffsmaschine). R. Gertz. A study of the possibility of using it in large ships. Illus. 2200 w. Schiffbau—Jan. 23, 1907. No. 83610 D.

Docks.

Modern Floating Docks. Lyonel Edwin Clark. Read before the Inst. of Naval Archts. A critical discussion of types now in use. 7000 w. Engng—April 5, 1907. No. 83744 A.

Dry Docks.

The Cavite Dry Dock at Sea. F. M. Bennett. Describes briefly some of the engineering problems that arose while the dock was in transit from the United States to the Philippine Islands. Ills.

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5500 w. Jour Am Soc of Nav Engrs—Feb., 1907. No. 83769 H.

The Railway Type of Dry Dock. James L. Crandall. An illustrated article discussing the essential features of a good dry dock, and presenting the advantages of the railway types. 2500 w. Int Marine Engng—April, 1907. No. 83344 C.

Fire Prevention.

The Causes and Prevention of Fire at Sea. Prof. Vivian B. Lewes. Read before the Inst. of Naval Archts. Considers the causes of fires at sea, the safeguards, and means of extinction. 6000 w. Engng—April 5, 1907. No. 83746 A.

Firing.

The Advantages of a Systematic and Regular Method of Working the Fires in a Boiler. R. K. Crank. Remarks on the advantages observed on two trial trips of ships, and gives suggestions for use on vessels where no automatic signals for working fires have been fitted. 1300 w. Jour Am Soc of Nav Engrs—Feb., 1907. No. 83772 H.

Freighter.

The New American Freighter Tuscan. George Jenkins. A single-screw steel freight steamer of the spar deck type, built for the highest class of the American Bureau of Shipping is illustrated and described. 2000 w. Int Marine Engng—April, 1907. No. 83345 C.

Gas Engines.

The Gas Engine for Heavy Marine Service. Lewis Nixon. Gives reasons for its adoption, and a short résumé of what has been done and the outlook. 1200 w. Engineering Magazine—May, 1907. No. 83933 B.

Gyroscope.

The Gyroscope as a Compass. A Frederick Collins. Illustrates and describes the Auschütz gyroscope, designed for the purpose of supplementing the ship's compass. 1100 w. Sci Am—April 6, 1907. No. 83460.

Lifeboat.

An Unsinkable Motor Lifeboat. L. Ramakers. Illustrated description of the "Michael Henry," built by John I. Thornycroft & Co., with report of tests. 500 w. Sci Am—April 6, 1907. No. 83461.

Lighthouse.

Armored Concrete Lighthouse at La Coubre, France. Illustrates and describes the construction of one of the highest light-towers in the world under difficult circumstances, in the short period of nine months. 1600 w. Engr, Lond—April 5, 1907. No. 83747 A.

"Lusitania."

The Cunard Liner "Lusitania." W. J. Luke. Read before the Inst. of Naval Archts. On some points of interest in connection with the design, building and launching of the "Lusitania." 6000 w. Engng—March 29, 1907. No. 83555 A.

Motor Boats.

Motor Boats at the Berlin and Paris Shows (Motorboote auf den Ausstellungen in Berlin und Paris). Auto Nautikus. Description of boats with particulars of the engines. Illus. 4600 w. Zeitschr des Mit Motorwagen Ver—No. 2, Jan., 1907. No. 83602 D.

Nautical Astronomy.

Nautical Astronomy Simplified. Clarence E. Long. Aims to show the usefulness of observing stars for azimuth in ascertaining the deviations of the compass, or for setting the course, giving some useful facts about Polaris and the Big Dipper. 12000 w. Marine Rev—March 28, 1907. No. 83347.

Propellers.

Propeller Struts. George Simpson. Read before the Inst. of Naval Archts. Paper aiming to induce a discussion on a semi-empirical formula, whose function is the determination of suitable dimensions for strut-arms by a definite method. 1500 w. Engng—April 5, 1907. No. 83745 A.

Torque of Propeller Shafting. J. Hamilton Gibson. Read before the Inst. of Naval Archts. Investigations and results of applying the torsion meter to propeller-shafting. 3000 w. Engng—April 12, 1907. No. 83882 A.

Effect of Number of Revolutions and Working Efficiency of Ships' Screws on the Speed (Die Aenderung der Umlaufzahl und des Wirkungsgrades von Schiffschrauben mit der Fahrgeschwindigkeit). H. Lorenz. Mathematical treatment, diagrams. 2700 w. Zeitschr d Ver Deutscher Ingenieure—March 2, 1907. No. 83608 D.

Salving.

The Salving of the Suevic. An illustrated account of the notable salving of this vessel, which was wrecked on the rocks off Lizard Point. 2700 w. Engr, Lond—April 12, 1907. No. 83886 A.

Signaling.

Submarine Signaling. Henry R. Gilson. An illustrated review of the development and the applications made. 2000 w. Elec Rev, N Y—March 30, 1907. No. 83349.

Finding Direction by Means of Submarine Sound Signals. Lucien J. Blake. A mathematical analysis of the sound waves received to determine whether the vessel casts a sound-shadow or not. 1700 w. Elec Wld—April 13, 1907. No. 83718.

Steadying Ships.

Gyroscopic Steadying Apparatus. Sir William H. White. Read before the Inst. of Naval Archts. Gives a summary of re-

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sults obtained with Dr. Otto Schlick's gyroscopic apparatus for steadying ships, and of the conclusions. Ills. 4500 w. Engng—April 5, 1907. No. 83743 A.

Steamers.

Details of the Three New Steamers Which Will Be Placed on the New York and Boston "Outside" Route by the New England Navigation Company. Profile, sections, and description of important new vessels. 1000 w. Naut Gaz—April 4, 1907. No. 83509.

The River Steamer S. S. Brown. H. H. Brown. Illustrated detailed description of a steel hull, western river packet boat recently built. 2500 w. Int Marine Engng—May, 1907. No. 83896 C.

Steamboating on the Mississippi. Frederick D. Herbert. An interesting illustrated account of the early history of navigation on this river, the types of vessels used, and the recent boats in this service. 2500 w. Int Marine Engng—May, 1907. No. 83897 C.

Submarines.

Safe Submarine Vessels and the Future of the Art. Simon Lake, before the Inst. of Naval Archts. An account of personal experiences and dangers encountered and overcome in experimental work with submarines; a statement of requirements to be met, and of the progress made. Ills. 3500 w. Engr, Lond—March 22, 1907. Serial. 1st part. No. 83431 A.

Tachometer.

Frahm's Resonance Tachometer and Its Use on War and Merchant Ships (Das Frahmsche Resonanztachometer und dessen Verwendung als Umdrehungsfernzeiger für Kreigs und Handelsschiffe). Friedrich Lux. Description of an ingenious electrical device for indicating the speed of a vessel. Illus. Serial. 3 parts. Schiffbau—Jan. 23, Feb. 13 and 27, 1907. No. 83609 each D.

Trials.

Trials of the Lubeck. R. Veith. Reports the trials of the first of the larger turbine ships. 3500 w. Jour Am Soc of Nav Engrs—Feb., 1907. No. 83771 H.

Turbines.

Steam Turbines for Ship Propulsion (Der Dampfturbinenantrieb von Schiffen). Felix Langen. Critical review of a number of turbines in marine service, with comparisons of performances. Serial, unfinished. 5 parts. Schiffbau—Jan. 9 and 23, Feb. 27, March 13 and 27, 1907. No. 83611 each D.

Warships.

The Influence of Machinery on the Gun Power of the Modern Warship. James McKechnie, before the Inst. of Naval Archts. Gives an analysis of the design of all machinery so far as it affects the fighting efficiency of the latest types of warships. Ills. 2800 w. Engr, Lond—March 22, 1907. No. 83430 A.

Wind Pressure.

Suggested Method for Experiments on the Wind Resistance of Ships. F. H. Alexander. Suggests a comparatively inexpensive method whereby some experiments might be carried out to increase the knowledge of the effect of wind's resistance on the vessel's speed. Plates. Also discussion. 3000 w. Trans N-E Coast Inst of Engrs & Shipbldrs—March, 1907. No. 83701 N.

MECHANICAL ENGINEERING

AUTOMOBILES.

Africa.

Use of Motor Cars in Africa (Die Verwendung der Selbstfahrer in Afrika). D. Kürchhoff. Discussion of the adoption of motor cars and the number of each kind in use at the present time. 3400 w. Zeitschr des Mit Motorwagen Ver—No. 2, Jan., 1907. No. 83603 D.

Benzine Motor.

Rate of Combustion in Benzine Locomotives (Die Feuergefährlichkeit der Benzinlokomotiven). Herr Beyling. Diagrams. 3800 w. Glückauf—Jan. 26, 1907. No. 83629 D.

Chain Drives.

Chain Drives and Their Care and Repair. Victor Lougheed. Discusses types of chain drives, their advantages and disadvantages, care, repair, etc. Ills. 2000 w. Automobile—April 11, 1907. No. 83572.

Change Gears.

Automobile Change Gears and Their Journals. Henry Hess. Read before Soc. Auto. Engrs., N. Y. The present article discusses a few principles in mounting ball bearings, illustrating a number of gears. 2000 w. Automobile—April 18, 1907. Serial. 1st part. No. 83792.

Couplings.

Universal Joints for Automobiles. E. J. Bartlett. Gives an analysis of the Hooke joint, and description of various types of universal couplings used in autocar construction. Ills. 3500 w. Am Mach—Vol. 30. No. 14. No. 83438.

Farm Work.

Motor Cars for Farm Work (Lastkraftwagen in der Landwirtschaft). A. Osch-

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mann. Specifications and descriptions of working vehicles for farm use. Illus. 7700 w. Zeitschr des Mit Motorwagen Vereins—No. 4, Feb., 1907. No. 83605 D.

Fuel.

A British Motor Fuel. Giving information in regard to benzol, its properties, possibilities and price. 2300 w. Autocar—April 6, 1907. No. 83732 A.

Fumes.

The Smoke Emission Trials. Illustrated description of the competing devices entered for the Vapor Emission Trials, and the tests to which they were subjected. 2500 w. Autocar—March 23, 1907. No. 83408 A.

Heavy Loads.

Motor Cars for Heavy Loads Shown at Paris (Lastautomobile im Pariser Salon 1906). Herbert Bauer. Detailed description of cars for transporting loads of from 3 to 6½ tons. Illus. 5700 w. Zeitschr des Mit Motorwagen Vereins—No. 3, Feb., 1907. No. 83604 D.

Ignition.

How the Magneto is Utilized for Ignition. Charles B. Hayward. Considers the different systems, characteristics of the current, how the time of ignition is altered, etc. Ills. 2000 w. Automobile—April 4, 1907. No. 83471.

Lubricants.

Lubricants for Motors. D. D. B. Glasgow. Discusses the advantages and disadvantages of various lubricants. 2500 w. Autocar—March 23, 1907. Serial. 1st part. No. 83409 A.

Magnets.

The New Lacoste H. T. Magneto. Illustrated description of a high-tension magneto shown at Olympia. 1200 w. Autocar—March 23, 1907. No. 83407 A.

Motor Problems.

Problems of the Motor Industry. Vivian B. Lewes. Abstract of a paper read before the Motor Yacht Club. The present article discusses fuels, especially alcohol. 3000 w. Auto Jour—March 23, 1907. Serial. 1st part. No. 83410 A.

Omnibuses.

Petrol Motor-Omnibuses. W. Worby Beaumont. An illustrated study of these vehicles, the design of the underframes, details of mechanism, etc., and some account of working costs. 12000 w. Inst of Mech Engrs—March 15, 1907. No. 83469 N.

The Darracq-Serpollet Steam 'Bus. An illustrated detailed description. 2200 w. Auto Jour—April 6, 1907. Serial. 1st part. No. 83730 A.

Transmission Gear for Motor Omnibuses (Das Getriebe der Automobil-Omnibusse). Robert Schwenke. Detailed description of transmission used on Daimler and other motor omnibuses. Illus. Serial. 1st part. 1400 w. Zeitschr d Mit Motorwagen Vereins—No. 23, Dec., 1906. No. 83666 D.

Racer.

America's Candidate for the Grand Prix. W. F. Bradley. An illustrated detailed description of the new Christie car. 1500 w. Automobile—April 11, 1907. No. 83571.

Renard Train.

The Renard and Sourcouf Road-Train System. Benjamin H. Thwaite and Richard F. Thorp. Reviews the development of the mechanical road transport system and describes in detail the motor road-train invented by Col. Renard. Ills. 7700 w. Soc of Engrs—April 8, 1907. No. 83790 N.

Shock Absorber.

The Suspension of Industrial Vehicles and Pneumatic Shock Absorbers (La Suspension des Vehicules Industriels et les Amortisseurs Pneumatiques). M. J. Patoureau. Illustrated detailed description of a new pneumatic shock absorber with mathematical discussion of the theory on which they are built. 6000 w. Mem Soc Ing Civ de France—Feb., 1907. No. 83676 G.

Simms-Welbeck.

The 30-35 H. P. Simms-Welbeck Car. Illustrates and describes a six-cylinder car of British manufacture. 2000 w. Autocar—April 6, 1907. No. 83731 A.

Starter.

The Saurer Self-Starter. Illustrated detailed description of a self-starting device invented by Herr Hippolyte Saurer. 1200 w. Autocar—March 30, 1907. No. 83541 A.

Steam Cars.

The Turner-Miesse Steam Car. Illustrates and describes a car of simple construction. 2500 w. Autocar—March 30, 1907. No. 83542 A.

Steam Vehicles.

Steam Motor Wagons at Olympia. Illustrates and describes particulars of some of the steam-operated vehicles shown. 1500 w. Mech Engr—March 23, 1907. Serial. 1st part. No. 83413 A.

Thames.

The 40-50 H. P. Thames Chassis. Illustrated detailed description of the chassis of the six-cylinder Thames car shown at Olympia. 1200 w. Autocar—March 23, 1907. No. 83405 A.

Tyres.

The Interchangeability of Tyres. Information from the principal tyre makers with regard to interchangeability and related subjects. 1800 w. Autocar—March 23, 1907. No. 83406 A.

Wheels.

The Heel of Achilles. G. Stuart Ogilvie.

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On resilient wheels in relation to the self-propelled road carriage. 1600 w. Autocar—April 6, 1907. Serial. 1st part. No. 83733 A.

COMBUSTION MOTORS.

Farm Engines.

The Use of Alcohol and Gasoline in Farm Engines. Prof. C. E. Lucke and S. M. Woodward. Discusses the cost of power from different sources, the comparative cost of energy in different fuels, thermal efficiency, adaptability of various types of engines and the first use of alcohol engines in the present number. 4500 w. Sci Am Sup—April 27, 1907. Serial. 1st part. No. 83916.

Fuel.

Some Phases of the Fuel Question. Prof. Vivian B. Lewes. Read before the Inst. of Naval Archts. Discusses the advantages of alcohol as a fuel, comparing the relative values of petroleum spirit and alcohol. 2500 w. Mech Engr—April 6, 1907. No. 83737 A.

Gas Engines.

Gas versus Steam. Louis Illmer, Jr. A comparison of the efficiency, economy and general advantages. 2500 w. Engr, U S A—April 15, 1907. No. 83777 C.

The Dangers of Gas Engines and Methods of Starting (Sui Pericoli dei Motori a Gas ed i Mezzi d'Avviamento). Francesco Massarelli. Discusses the dangers of self-starting engines and the advantages of using compressed air. Ill. Serial. 1st part. 2800 w. L'Industria—March 17, 1907. No. 83680 D.

Automobile Engine Building in a Steam Engine Plant. Illustrates and describes methods of the Providence Engineering Works in the manufacture of about two thousand double-opposed-cylinder automobile gas engines, with the accompanying speed change mechanism, differential gearing, and other related parts. 3500 w. Mach, N Y—April, 1907. No. 83390 C.

Hurd & Haggin Marine and Railway Engine. Illustrated description of a new marine and railway gas engine exhibited at the last Motor Boat Exhibition in New York. 1300 w. Mach, N Y—April, 1907. No. 83391 C.

Gas Producers.

The Utilization of Low Grade Fuel in Gas Producers. F. E. Junge. Discusses the preservation of the fuel supply, the economic features of fuel utilization, the gasification of fuels, and related subjects. 4000 w. Ir Trd Rev—April 4, 1907. Serial. 1st part. No. 83474.

Notes on the Utilization of Poor Coals and Slack. D. B. Dowling. Shows that even the poorest lignite has, as a gas producer, a value equal in power production to that of a good steam coal when used in the steam plant. Discussion. 3000 w. Jour Can Min Inst—1906. No. 83820 N.

Gas Turbines.

Gas Turbines (Les Turbines à Gaz). F. Naive. General details of gas turbine design, their operation, applications, etc. Ill. 2400 w. L'Alliance Industrielle—April, 1907. No. 83686 D.

Gas Washer.

A Stationary Centrifugal Gas Washer. Illustrated description of the Bachman washer, which cleans gas in the same way the Stratton steam separator removes water from steam. 1000 w. Ir Age—April 11, 1907. No. 83557.

Petrol.

The Horse-Power of the Petrol Motor. F. W. Lanchester. Read before the Inst. of Auto. Engrs. Discusses its relation to bore, stroke, and weight, the argument being based on the dimensional theory. 4000 w. Autocar—April 20, 1907. Serial. 1st part. No. 83986 A.

Two-Cycle Engines.

The Two-Cycle Combustion Engine. James McIntosh. Reviews different features capable of improvement, and discusses how to make a success of the two-cycle engine. 2500 w. Ir Trd Rev—April 25, 1907. No. 83960.

HEATING AND COOLING.

Central Plant.

Central Heating System for Fifty-one Detached Buildings. Illustrated description of the central power plant, hot-water heating system and hot-water supply system for the New York Juvenile Asylum, Dobbs Ferry, New York. 2200 w. Heat & Vent Mag—April, 1907. No. 83855.

Modern Methods.

Modern Methods of Heating and Ventilation. A. G. King. The first of a series of articles dealing with this subject in a practical manner. 1800 w. Archts & Bldrs Mag—April, 1907. Serial. 1st part. No. 83774 C.

Refrigeration.

Clearance in a Refrigerating Machine. Oswald Gueth. Calls attention to losses of work in a compressor because of clearance and the effect of the design in curtailing these losses. Ills. 1700 w. Engr, U S A—April 1, 1907. No. 83385 C.

Preliminary Report of the Committee on a Code of Rules for Conducting Tests of Refrigerating Machines. 4500 w. Pro Am Soc of Mech Engrs—April, 1907. No. 83760.

Steam Heating.

Arrangement of Steam Heating Apparatus for Pressure from a Low-Pressure Steam Boiler (Die Anordnung von Dampfheizapparaten innerhalb der Druckhöhe von Niederdruckdampfkesseln). M. Grellert. Diagram and formulae. 3100 w.

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Gesundheits Ingenieur—Feb. 2, 1907. No. 83607 D.

Ventilation.

Air, and Its Relation to Vital Energy. S. H. Woodbridge. A comparison between the requirements of mechanical and vital systems, showing the great importance of an adequate supply of pure air. 3500 w. Dom Engng—April 6, 1907. Serial. 1st part. No. 83507.

Ventilators.

Comparison of Recent Ventilators with A. C. Motor Drives and Variable Speed (Vergleichende Untersuchungen an neuern Capellventilatoren mit Drehstromantrieb und veränderlicher Umlaufgeschwindigkeit). R. Goetze. Illus. 2900 w. Glückauf—March 30, 1907. No. 83667 D.

Water Heaters.

Types of Enclosed Steam Water Heaters. C. R. Allensby. Read before the Cic. & Mech. Engrs. Soc. Illustrates and describes the construction of some of the familiar types of heaters. 2500 w. Mech Engr—March 23, 1907. Serial. 1st part. No. 83415 A.

HYDRAULICS.

Pumps.

An Ancient Roman Pump. Illustrates and describes a well discovered in German Lorraine, near the village Sablon. 800 w. Sci Am Sup—April 6, 1907. No. 83464.

Pumping Devices for Open Tank Service. W. H. Wakeman. Illustrates and describes automatic devices for controlling the delivery of water to roof tanks. 1200 w. Sci Am Sup—April 13, 1907. No. 83581.

Turbines.

Large Modern Water Turbine Plants (Grosse moderne Turbinenanlagen). L. Zodel. Description of a 3,000 h.p. station for generating electricity at Verona, Italy. Illus. Serial. 2 parts. 3000 w. Schweizerische Bauzeitung—Jan. 26 and Feb. 2, 1907. No. 83620 each B.

MACHINE WORKS AND FOUNDRIES.

Air Furnace.

The Air Furnace in Grey-iron Founding. Hugh Dolnar. Showing its advantages where it is desirable to obtain uniform mixtures for any work and giving details of a successful furnace. Ills. 1200 w. Am Mach—April 18, 1907. No. 83781.

Armor.

Modern Armor and Armor-Piercing Projectiles. H. J. Jones. The present article describes the manufacture of modern armor plates. 2800 w. Engr, Lond—April 12, 1907. Serial. 1st part. No. 83884 A.

Bearings.

Construction of Conical Roller Bearings. Hugh Dolnar. An illustrated account of the practice at the Timken Roller Bearing Company's shops at Canton, O. 1600 w. Am Mach—Vol. 30, No. 17. No. 83900.

A Fixture Used in Pouring White-Metal Bearings. Charles Prescott Fuller. Illustrates and describes a device carrying a pair of arbors and a series of collapsible bushings around which the metal bearings are run. 3000 w. Am Mach—Vol. 30, No. 16. No. 83780.

Bell Casting.

How Church Bells Are Cast. F. P. Lotz. An illustrated description of the process of bell-founding. 1200 w. Sci Am—April 6, 1907. No. 83459.

Boiler Fittings.

Steel Castings for Boiler Fittings. Abstract of a paper read by Captain Ira Harris at the meeting of the Board of Supervising Inspectors, Steamboat Inspection Service. 2500 w. Boiler Maker—April, 1907. No. 83388.

Brass.

Use of a Block of Wood in Casting Brass for Rolling. Discusses the trouble from the presence of "spills," the cause, and remedy, and the value of the wood block on the surface of the brass in the crucible. Ills. 1200 w. Brass Wld—April, 1907. No. 83927.

Crucibles.

Crucibles—Their Care and Use. John A. Walker. An illustrated article on the keeping and handling of crucibles in a manner that will insure the greatest number of heats with the least danger of accidents. 3000 w. Ind Wld—April 6, 1907. No. 83508.

Cutting Metals.

The Art of Cutting Metals. Contribution to the discussion of paper by F. W. Taylor. 13500 w. Pro Am Soc of Mech Engrs—April, 1907. No. 83762 D.

Drills.

The Thrust of Twist Drills. Henry Hess. Gives a diagram and a formula for thrusts, with remarks. 900 w. Am Mach—Vol. 30, No. 17. No. 83903.

Fly-Wheels.

The Haight Fly-wheel Joint Indorsed. C. H. Benjamin and W. H. Boehm. An illustrated article giving examples showing weakness of fly-wheel joints and suggestions for making the joints as strong as the rims. 2500 w. Am Mach—Vol. 30, No. 15. No. 83560.

Foundries.

Cost of Equipping Foundries for the Manufacture of Open-Hearth Steel Castings. W. M. Carr. Gives an estimate

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based on the daily capacity. 900 w. Ir Trd Rev—April 11, 1907. No. 83568.

Starting a Foundry. Walter J. May. Suggestions for the proper arrangement and equipment. 2300 w. Prac Engr—April 5, 1907. No. 83734 A.

Design of a Cast Iron Pipe Foundry. J. B. Nau. Drawing and description of some new features in a design made by the writer several years ago. 1300 w. Ir Age—April 4, 1907. No. 83434.

New Plant of the Detroit Steel Casting Company. Illustrated description of a well-equipped foundry for the manufacture of open hearth and converter steel castings. 3000 w. Foundry—April, 1907. No. 83593.

Equipment of Pipe Foundries (Entwicklung der Anlage von Röhrengiessereien). Gustav Simon. Foundry arrangements and devices in use in Austria and Germany described. Illus. 2800 w. Stahl und Eisen—Mar. 20, 1907. No. 83622 D.

Foundry Mixtures.

Fluxes and Alloys. Alexander E. Outerbridge, Jr. Read before the Pittsburgh Found. Assn. Discusses the function of fluxes in the cupola, and their effect upon the melting and properties of pig iron; and a discussion of alloys of metal with cast iron. 4000 w. Ir Age—April 11, 1907. No. 83559.

Galvanized Iron.

The Manufacture of Galvanized Sheet Iron (Fabrication de la Tôle Galvanisée). The Machet machine for galvanizing sheet iron, its construction and operation, and a comparison of this process with ordinary methods. Ill. 4400 w. Mem Soc Ing Civ de France—Feb., 1907. No. 83675 G.

Theory and Practice of Sherardizing. Alfred Sang. Discusses this dry galvanizing process, especially in its theoretical aspects. 3000 w. Elec-Chem & Met Ind—May, 1907. No. 83981 C.

Gas Pipe.

Manufacture of Drawn Gas Pipe (Zur Fabrikation gezogener Gasröhre). Anton Bousse. Description of machines and processes employed. Illus. Serial. 1st and 2d parts. 8000 w. Stahl und Eisen—Mar. 13 and Mar. 20, 1907. No. 83621 each D.

Gears.

Laying Out and Machining Elliptical Gears. Gives the writer's experience in the construction of single-lobe gears. Ills. 1300 w. Am Mach—Vol. 30, No. 14. No. 83439.

Modern Gear-Cutting Machinery. Joseph Horner. Considers present developments in these machines, illustrating and describing special machines of interest. 4000 w. Cassier's Mag—April, 1907. No. 83334 B.

Jigs.

Pneumatic Clamp Drilling Jig. O. C. Bornholt. Illustrated description of a pneumatic clamp drilling jig which was designed for holding small castings, pinions, spur gears, pulleys, etc., for reaming or drilling. 700 w. Mach, N Y—April, 1907. No. 83393 C.

Correcting a Drilling Jig. Walter Gribben and Gus Weinmann. Explains how an accurate job was done with common measuring appliances. 2000 w. Am Mach—Vol. 30, No. 17. No. 83901.

Lathes.

Some Engine-lathe Details. Illustrates and describes details of bed, headstock, and carriage apron. 1000 w. Am Mach—Vol. 30, No. 15. No. 83562.

Motor-driven Automatic Turret Lathe. D. H. Parker. Illustrated description of a machine using automatically controlled variable-speed motors for operating the spindle and cam drum shaft at any desired speed. 700 w. Am Mech—April 18, 1907. No. 83782.

Molding.

Molding a Double Flange Pulley by Machine. C. R. McGohey. Brief illustrated description of a difficult job successfully accomplished. 400 w. Foundry—April, 1907. No. 83592.

A Molding Job with a Green-sand Core. W. W. McCarthy. Illustrates and describes the molding of a newel post for the stairway of the Majestic Hotel, Atlanta, Ga. 1000 w. Am Mach—Vol. 30, No. 17. No. 83902.

Molding Machines.

The Molding Machine in Actual Practice. R. H. Palmer. Considers its adaptability to general work, the percentage of poor castings, and its improvement through co-operation of molders. 4000 w. Am Mach—Vol. 30, No. 14. No. 83440.

Patterns.

Collapsible Patterns. H. J. McCaslin. Illustrates and describes the molding of a surface condenser, as an example of the advantages and possibilities of collapsible patterns. 2500 w. Foundry—April, 1907. No. 83594.

Planer.

A Large Pit Planer. Illustrations, with brief description of a pit planer built for finishing the four edges of armor plate, 24 ft. long by 12 ft. wide by 12 ins. thick at one setting. 700 w. Am Mach—Vol. 30, No. 15. No. 83561.

Press Tool.

A Combination Press Tool for Tin Box Lids. G. Thorne. Illustrated description

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of a tool used in producing tin lids or caps. 1200 w. Prac Engr—April 19, 1907. No. 83987 A.

Repairing.

Burning a New Jaw on a Heavy Shear. Brief illustrated description of the use of thermit for heating the fractured surface to the fusing point before pouring the cast iron. 500 w. Am Mach—Vol. 30, No. 16. No. 83778.

Screw Cutting.

Gearing Up a Lathe for Screw Cutting. Fred H. Colvin. An explanation of the principle. 1200 w. Ry & Loc Engng—April, 1907. No. 83530 C.

Shops.

The Drop Forge and Hardening Plant. Edward H. McClintock. Illustrates and describes a type of each department, indicating the writer's idea of what constitutes best modern practice. 3000 w. Mach, N Y—April, 1907. No. 83389 C.

Threading Tools.

Measuring Width of Flat on U. S. Standard Thread Tools. Erik Oberg. Explains a method of measuring by a simply designed micrometer, giving tables and diagrams. 1000 w. Mach, N Y—April, 1907. No. 83392 C.

Welding.

Welding and Soldering. Electric Welding Machines for Workshops (Schweissen und Löten. Elektrische Schweissmaschinen für Massenfabrikation). Herr Peter. Description of electric welding apparatus and methods of operation. Illus. Serial. First and second instalments. 6000 w. Glaser's Annalen—Feb. 1 and Feb. 15, 1907. No. 83618 each D.

Works.

Werf Gusto. An illustrated detailed description of these engineering works at Schiedam, Holland, and some of the excavators, dredgers, floating docks and other productions of the firm. 4000 w. Engng—April 5, 1907. Serial. 1st part. No. 83742 A.

Worms.

Making Worms in a Molding Machine. Robert Patten. Half-tones and sketches showing the special devices used in the work. 1100 w. Am Mach—Vol. 30, No. 16. No. 83779.

MATERIALS OF CONSTRUCTION.

Alloys.

Light Aluminum Alloys. J. E. Stacey Jones. Abstract of a paper read before the Coventry Engng. Soc. Describes these alloys, their founding and treatment, and methods of testing. 2500 w. Ir & Coal Trds Rev—April 12, 1907. No. 83889 A.

Cast Iron.

Tensile Testing of Cast Iron. F. J. Cook. Abstract of a paper read before the Birmingham Assn. of Mech. Engrs. Considers characteristics of cast iron in regard to tensile strength. 5500 w. Mech Engr—April 13, 1907. No. 83868 A.

Copper Substitutes.

Substitutes for Copper. Calls attention to the present demand for copper, its high price, and the need of substitution or alloying, and explains the advantages claimed for the Monnot process, especially the copper clad wire. 1400 w. Ir Age—April 4, 1907. No. 83436.

Muntz Metal.

Report on the Decay and Corrosion of Muntz Metal. W. M. Hamlet. Research work to discover the cause of corrosion and decay of this metal, which is an alloy of zinc and copper used for the protection of ships' bottoms against barnacles, seaweed and other forms of marine life. 900 w. Min Jour—April 13, 1907. Serial. 1st part. No. 83877 A.

Rails.

Steel Rails. T. S. Griffiths. Discusses present methods of steel making and the effect on the product, and the causes of inferiority of rails of the present as compared with rails made 10 years ago. 3000 w. Can Engr—April 5, 1907. No. 83505.

Testing.

Brinell's Method for Testing the Hardness of Metals. J. E. Stead and T. Greville-Jones. Description and results of this method, which consists in forcing a hard steel ball into the material to be tested under a given pressure, measuring the depression. 1300 w. Ir & Coal Trds Rev—April 12, 1907. No. 83888 A.

Time-Factor.

The Time-Factor in the Resistance of Materials. Editorial on the effect of the time-factor, referring to recent paper by Mr. Stromeyer. 2200 w. Engng—March 22, 1907. No. 83484 A.

Wrought Iron.

The Structure of Wrought Iron. Albert Sauveur. Gives reproductions of typical drawings and photomicrographs illustrating and describing the structure clearly. 800 w. Elec-Chem & Met Ind—April, 1907. No. 83538 C.

MEASUREMENT.

Comparator.

Mirror Comparator (Comparateur á Miroir). Joseph Rodet. A description of the construction of this instrument for measuring small displacements and a mathematical discussion of its use. Ill. 1200 w. L'Elec'n—March 30, 1907. No. 83691 D.

Shearing Strains.

Shearing Strains in the Material of Rotating Bodies (Ueber die Materialbeanspruchung in rotienenden Körpern). Edmund Röggla. Mathematical treatment. Diagrams. 3000 w. Zeitschr d Oesterr

Ing u Arch Vereines—March 8, 1907. No. 83657 D.

Testing Machines.

Electric Beam Balancing Device for Testing Machines. Illustrates and describes an automatic beam-balancing apparatus devised by G. A. Julius for use in making a large number of tests on the mechanical properties of Australian timbers. 1500 w. Elec Engr, Lond—April 5, 1907. No. 83738 A.

Torsiometers.

Torsiometers as Applied to the Measurement of Power in Turbines and Reciprocating Engines. Archibald Denny. Read before the Inst. of Naval Archts. Illustrates and describes instruments used on turbine engines to determine their efficiency. 2200 w. Mech Engr—April 6, 1907. No. 83736 A.

Turbine Rotors.

The Static Deflection of Turbine Rotors. R. H. Collingham. Shows how, by the aid of graphics, the deflection of any body of varying section, such as a turbine rotor, may be arrived at with a sufficient degree of accuracy for all practical purposes. 2000 w. Engr, Lond—March 29, 1907. No. 83550 A.

POWER AND TRANSMISSION.

Central Plant.

The Central Power Plant at St. Paul's School, Concord, N. H. Plans and description of a plant to furnish heat and light to a group of about 25 buildings. 2800 w. Eng Rec—April 6, 1907. No. 83483.

Cranes.

Cranes for Shipbuilding Berths. Carlo Piaggio. Read before the Inst. of Naval Archts. Gives an illustrated description of the electric cranes at the Riva shipyard. 1000 w. Mech Engr—April 6, 1907. No. 83735 A.

Design and Construction of Electric Overhead Travelling Cranes. Read before the Grad. Assn. of the Inst. of Mech. Engrs. Considers only the multi-motor type with fixed gantry, giving illustrations. 2800 w. Mech Engr—March 23, 1907. No. 83414 A.

The Control of Cranes. E. G. Fiegehen. Discusses in their order the cycle of operations, with suggestions for skilful control. 2500 w. Prac Engr—April 12, 1907. No. 83866 A.

Drive.

A Novel Drive for a Grinding Machine. H. F. Noyes. Illustrated description of a rope drive arranged in an interesting manner for operating the emery wheel of a grinding machine with long bed. 600 w. Am Mach—Vol. 30, No. 17. No. 83904.

Electric Drive.

Motors for Machines and Tools. Dana Pierce. A comparison of the electric drive with the steam drive or water drive by belting and shafting, considering the advantages of the use of electricity in mills and workshops. 2800 w. Ins Engng—March, 1907. No. 83587 C.

Handling Appliances.

Special Handling Appliances for the Shop. H. M. Lane. Illustrates and describes the truck and crane systems of the B. F. Sturtevant Company, Hyde Park, Mass. 2200 w. Ir Age—April 4, 1907. No. 83433.

Power Plants.

Power Plant of the Santa Fe Grain Elevator. Illustrations and brief description of this Chicago plant and the large machinery installation to give great handling capacity. 2000 w. Engr, U S A—April 15, 1907. No. 83776 C.

Power Plant of the Sperry Flour Co., Los Angeles, Cal. W. F. Durand. States the conditions under which the plant must operate, and gives a detailed description of the plant installed, and test results. 3000 w. Eng Rec—March 30, 1907. No. 83367.

Hydro-Electric Power versus Steam for Industrial Plants. H. von Schon. This second article of a series discusses the development of water power as a commercial enterprise. 5000 w. Engineering Magazine—May, 1907. No. 83936 B.

Rope Railway.

A Wire Rope Railway Used in the Construction of an Italian Fortress. Dr. Alfred Gradenwitz. Illustrated description of a ropeway remarkable for its enormous spans and for the great altitude it reaches. 1200 w. Sci Am—April 6, 1907. No 83462.

STEAM ENGINEERING.

Boiler House.

The North Boiler House of Swift & Co. in the Union Stock Yards, Chicago. Illustrated description of a new boiler house having a capacity of 5600 h. p., and its equipment. 4800 w. Eng Rec—April 6, 1907. No. 83480.

Corrosion.

See Marine and Naval Engineering.

Explosions.

The Lap Joint in Boilers. H. S. Brown. Discusses whether lap joints are responsible for boiler explosions. Explains the weak points of lap joints, but states that many troubles have been charged to them for which they are not responsible. Ills. 3500 w. Ir Age—April 18, 1907. No. 83757.

Firing.

Underfeed Firing (Unterschubfeuerungen). A. Pradel. Description of furnaces built for both hand and mechanical underfeed. Illus. 3300 w. Gesundheits Ingenieur—March 30, 1907. No. 83643 D.

Gouy's Theorem.

Gouy's Theorem and Some of Its Applications (Le Théorème de M. Gouy et quelques-unes de ses Applications). E. Jouquet. A mathematical discussion of Gouy's Theorem and of its application to compressed air and steam machines. Ill. 14400 w. Rev de Méch—March 31, 1907. No. 83682 E + F.

Heat.

Heat Power. John Batey. Brief discussion of heat in regard to the steam engine, giving suggestions for increasing the efficiency. 2400 w. Prac Engr—March 22, 1907. No. 83411 A.

Heat Loss.

The Heat Transmission Loss Due to Boiler Scale and Its Relation to Scale Thickness. Gives data and results of tests made at the Engineering Experiment Station of the College of Engineering of the University of Illinois. Also general discussion. Ills. 15500 w. Pro W Ry Club —March 19, 1907. No. 83753 C.

High Temperatures.

Thermal Properties of Water and Steam at High Temperatures. Deals with researches by Prof. C. Dieterici, of the Technical High School of Hanover; and of Prof. Oscar Knoblauch and Dr. Max Jacob of Munich. 2000 w. Engng—March 15, 1907. Serial. 1st part. No. 83466 A.

Mechanical Draft.

Fans for Draft, Forced and Induced. Charles L. Hubbard. Directions for calculating proportions and capacity of fans, the horse-power required, and the volume of air delivered. Diagrams. 2500 w. Power—May, 1907. Serial. 1st part. No. 83861 C.

The Application of the Fan Blower to Mechanical Draft. Carl S. Dow. A discussion of the blower system of forced or induced draft, illustrating some of the fans used. 3500 w. Harvard Eng Jour—April, 1907. No. 83789 D.

Piping.

Troubles Caused by Faulty Piping Work. H. A. Jahnke. Examples of mistakes made by engineers and fitters, and suggestions how to remedy or avoid them. Ills. 2500 w. Power—May, 1907. No. 83862 C.

Smoke.

Smokeless Furnaces and Smoke Suppression. A. Bement. Abstract from the Peabody Atlas, explaining the conditions for perfect combustion and methods of burning fuel. Ills. 2500 w. Engr, U S A —April 1, 1907. No. 83384 C.

Smoke Prevention in Factories and Electric Supply Stations. John B. C. Kershaw. Describes the principles underlying the methods by which fuel may be burned without smoke-production, giving an account of the work of a Smoke Abatement Society. Also discussion. 7000 w. Jour Soc of Arts—March 22, 1907. No. 83404 A.

Steam.

The Economical Generation and Use of Steam. The present articles considers the economy possible in the generation of the steam. 2500 w. Prac Engr—April 12, 1907. Serial. 1st part. No. 83867 A.

Steam Trap.

Testing a Steam Trap at High Pressures. An illustrated account of tests made of a steam trap operating at 375 pounds pressure. 900 w. Engr, U S A—April 1, 1907. No. 83387 C.

Superheating.

Specific Heat of Superheated Steam. A. R. Dodge. Presents two of the methods employed by the writer in making investigations, describing apparatus, and discussing results. Diagrams. 2800 w. Pro Am Soc of Mech Engrs—April, 1907. No. 83761.

Present Practice in the Use of Superheated Steam. Reginald Pelham Bolton. This third and concluding article of a series discusses locomotive and marine applications and superheater design. A bibliography of the contributions to this subject is appended. Ills. 2500 w. Engineering Magazine—May, 1907. No. 83938 B.

Turbines.

Systematic Symbols in Turbine Design (Einheitliche Bezeichnung im Turbinenbau). Olof Linders. A proposed set of symbols for physical properties, energy, etc. 2400 w. Zeitschr f d Gesamte Turbinenwesen—March 20, 1907. No. 83630 D.

Improvements in the Laval Turbine (Die Vervollkomnung der Lavalturbine). Felix Langen. Account of changes in the design of details, to increase the efficiency. Tables. Serial. 3 parts. 5000 w. Zeitschr f d Gesamte Turbinenwesen—March 9, 20, and 30, 1907. No. 83631 each D.

The Curtis Turbine (Die A. E. G. Curtis Turbine). O. Lasche. Comprehensive description of the Curtis turbine as built by the Allgemeine Elektricitats Gesellschaft, for stationary and marine purposes. Illus. 7600 w. Schiffbau—March 27, 1907. No. 83628 D.

Valve Gears.

A New Form of Automatic Assistant Cylinder for Valve Gears. Luther D. Lovekin. Illustrated description of the improved "assistant cylinder" for valve gears designed by the writer. 900 w. Jour Am Soc of Nav Engrs—Feb., 1907. No. 83773 H.

Valves.

Connecting Up Valves. William Kavanagh. Shows some incorrect connections and the means by which they can be rectified. Ills. 1200 w. Elec Wld—April 6, 1907. No. 83502.

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MINING AND METALLURGY

COAL AND COKE.

Accounting.

See Industrial Economy.

Alberta.

The Coals and Coal Fields of Alberta, Saskatchewan and Manitoba. D. B. Dowling. A résumé of the extent and character of the coals found in these fields. 2000 w. Can Min Jour—April 15, 1907. No. 83796.

Anthracite.

The North Shaft Mine of the Susquehanna Coal Co., at Nanticoke, Pa. E. E. Winter. Describes the geology of the district, the mining plant and methods of mining, timbering, ventilating, etc. 3000 w. Jour Can Min Inst—1906. No. 83822 N.

Breaker.

Anthracite Breaker of the Pacific Coal Company, Limited, Bankhead, Alberta. Lewis Stockett and B. R. Warden. A description, with drawings and photographs of the building and machinery. 3200 w. Jour Can Min Inst—1906. No. 83817 N.

British Columbia.

Some Notes on the Economic Geology of the Skeena River. W. W. Leach. From the *Jour. of the Can. Min. Inst., Vol X.* Explains the rich possibilities of this region, lacking development for need of transportation facilities. Coal and metalliferous deposits have been located. 4000 w. B C Min Rec—Feb., 1907. No. 83-783 B.

Coal Storage.

Under Water Coal Storage. Illustrated description of the arrangements made by the Western Electric Company of Chicago. 600 w. Ry & Loc Engng—April, 1907. No. 83533 C.

Coke.

Coking Freeport Coals in Preston County, West Virginia. J. B. Hanford. Read before the Coal Min. Inst. of America. Explains the development of the process for making these coals into high-grade coke. Ills. 2500 w. Mines & Min—April, 1907. No. 83398 C.

Colliery.

Number Four Pit—Brayton Domain Collieries, Cumberland, England. R. P. Cowen. Prize paper. Illustrated description of methods of mining, timbering, lighting, drainage, etc., at this bituminous coal mine. 2500 w. Jour Can Min Inst—1906. No. 83825 N.

Electric Drive.

Central Electric Drive for Collieries. Franz Erich Junge. Explains the advantages of the central power system for coal mines and coke-oven plants whether steam or gas engines are used. 3800 w. Eng & Min Jour—April 13, 1907. No. 83713.

Essen.

The New Essen and Gelsenkirchen Deposits (Die Neuern Ausschlüsse im Osten der Essener Mulde und des Gelsenkirchener Sattels bis zur Linie Olfen-Lünen). Herr Hilgenstock. A German coal deposit. Illus. Maps. 5300 w. Glückauf—Feb. 2, 1907. No. 83662 D.

Explosions.

Mine Explosions in Illinois. Hon. Richard Newsam. An account of three explosions from excessive use of powder, where neither gas nor coal dust were present. 2000 w. Mines & Min—April, 1907. No. 83401 C.

Wingate Grange Colliery Explosion. Information from the Home Office report of this explosion, which occurred in October, 1906. 5500 w. Col Guard—March 22, 1907. No. 83423 A.

Comments on the Courrières Mine Disaster (Einige Betrachtungen anlässlich der Katastrophen in Courrières und auf Grube Reden). J. Mayer. Serial. 2 parts. 5900 w. Oesterr Zeitschr f Berg und Hüttenwesen—March 16 and 23, 1907. No. 83658 each D.

Explosives.

Explosives in Coal Mines. Report of the Departmental Committee on bobbinite. 7500 w. Col Guard—April 12, 1907. No. 83878 A.

Gas Power.

Economy of Gas Power Plants for Collieries. Franz Erich Junge. Explains the advantages of electric distribution of power from a central gas-engine installation using waste gases and culm. 4500 w. Eng & Min Jour—April 27, 1907. No. 83968.

Haulage.

Endless Rope Haulage. B. Harrison. Gives particulars in regard to the overtub endless-rope haulage of the Silkstone seam at the West Riding collieries. Ills. 2800 w. Min Wld—April 13, 1907. No. 83724.

Kentucky.

Mining in Cumberland Gap Coalfield. John Leggett Pultz. Map, with description of this field, the deposits and methods of mining. 3000 w. Eng & Min Jour—April 27, 1907. No. 83970.

Keps.

Keps. James Tonge. A description and criticism of the best known keps, for supporting cages in winding shafts, used in Great Britain and on the Continent. Ills. 4000 w. Ir & Coal Trds Rev—April 5, 1907. No. 83751 A.

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Longwall.

Mining Anthracite by Longwall. Describes an application of the method under conditions rendered difficult by previous working above and below. Ills. 1700 w. Mines & Min—April, 1907. No. 83394 C.

The Effects of Roof Pressures in Longwall Workings. Henry Briggs. Describes methods of taking advantage of them to bring down the coal without blasting. Ills. 3000 w. Mines & Min—April, 1907. No. 83395 C.

Managers.

The Colliery Manager. William D. L. Hardie. Explains some of the present difficulties to be encountered, the information needed, and the wisdom of keeping an index of articles on subjects relating to the work. 4000 w. Jour Can Min Inst—1906. No. 83814 N.

Mine Flooding.

Report on the Inundation of Water at Caradog Vale Colliery. From the Home Office report of this disaster which occurred on June 26, 1906. 2000 w. Col Guard—March 22, 1907. No. 83424 A.

Mine Plant.

Plant of the Berwind-White Coal Company's No. 40 Mine. Illustrated detailed description of an electrical mine plant in Pennsylvania, with modern coal and labor saving equipment. 2500 w. Engr, U S A —April 1, 1907. No. 83383 C.

Ohio.

Methods of Working the Coal Seams of Ohio. Floyd W. Parsons. Illustrates and describes mining in the Hocking Valley field, where an overlying stratum of quicksand makes it impossible to rob pillars and permit the surface to cave in. 2000 w. Eng & Min Jour—April 20, 1907. No. 83840.

Pennsylvania.

Geology of the Buck Mountain Coal Bed. Harry W. Althouse. Describes this formation in Pennsylvania, and the method of working. Ills. 1200 w. Eng & Min Jour—April 6, 1907. No. 83520.

Rescue Apparatus.

Rescue Apparatus at Collieries. Reviews two recent papers by M. Weiss before the Paris Section of the Soc. de l'Ind. Min. relating to the use of rescue apparatus in mines. Ills. 4000 w. Col Guard—March 29, 1907. No. 83549 A.

New Types of Rescue Apparatus in Mines (Nouveaux Appareils de Sauvetage dans les Mines). H. Schwerber. Descriptions of several devices for supplying oxygen to rescuers in mines. Ill. Serial. 1st part. 3000 w. Génie Civil—March 30, 1907. No. 83695 D.

The "Aerolith" Life Saving Appliance (Ueber den Rettungsapparat "Aerolith"). Josef Popper. Description of the Suess patent device for liberating oxygen in gas or smoke-filled places. Serial. 2 parts. 3800 w. Oesterr Zeitschr f Berg und Hüttenwesen—March 23 and 30, 1907. No. 83660 each D.

Testing.

Specific Gravity of Coal as a Measure of Purity. M. S. Hachita. Explains a practical application of this method of testing. 900 w. Eng & Min Jour—April 6, 1907. No. 83521.

Winding Plant.

Electric Winding Plant at a German Colliery. Alfred Gradenwitz. Illustrates and describes the Ilgner system with starting motor and fly-wheel equalizer, as employed at Neindorf. 2500 w. Eng & Min Jour—April 13, 1907. No. 83716.

COPPER.

B. C. Copper Co.

The British Columbia Copper Company's Mines and Smelter. Francis G. Wickware. Gives the history of the development of the company, nature of the ore, geology of the deposit, methods of mining and smelting and detailed description of the entire plant. Ill. 10000 w. Jour Can Min Inst—1906. No. 83821 N.

British Columbia.

The Boundary District, British Columbia. Forbes Rickard. An illustrated description of this district and its ores of the precious metals. 2000 w. Min & Sci Pr—April 20, 1907. No. 83966.

Copper Ores.

Some New Points in the Geology of Copper Ores. James F. Kemp. Read before the Can. Min. Inst. Calls attention to the most productive copper-bearing minerals, showing that recent discoveries have made necessary a change in old views. 2000 w. Min & Sci Pr—March 30, 1907. No. 83442.

Idaho.

The Lost Packer Copper Gold Lode. E. P. Jennings. A description of this remarkable lode, located 25 miles northwest of Custer, Idaho. The ore is chalcopyrite containing from 2 to 20 ozs. of gold and a small amount of silver. 1200 w. Jour Can Min Inst—1906. No. 83803 N.

Mexico.

The Cananea Copper Deposits. Robert B. Brinsmade. An illustrated account of the early discoveries and work, the extent and richness of the ore bodies, and the mining methods. 2300 w. Mines & Min April, 1907. Serial. 1st part. No. 83403 C.

Occurrences.

Some Observations Relative to the Occurrence of Deposits of Copper Ore on Vancouver Island, and Other Portions of the Pacific Coast. William M. Brewer. Gives an outline of the character and extent of these deposits. 3800 w. Jour Can Min Inst—1906. No. 83801 N.

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Occurrence of Copper Ore on the North Pacific Coast. William M. Brewer. Information concerning the deposits of copper ore found on the North Pacific coast and adjacent islands. 5500 w. B C Min Rec—Feb., 1907. No. 83785 B.

Ontario.

The Bruce Mines, Ontario, 1846-1906. H. J. Carnegie Williams. An illustrated historical review of these copper mines. 4000 w. Can Min Jour—April 1, 1907. No. 83511.

Production.

The Production and Price of Copper for the Period 1889-1906. John B. C. Kershaw. An examination of the statistics of the world's copper production for the past 18 years, and the future outlook as regards production and price. 2500 w. Elect'n, Lond—April 19, 1907. No. 83-994 A.

Queensland.

Cloncurry Copper District. Lionel C. Ball. Notes from a report made recently after inspecting this field. 1200 w. Aust Min Stand—March 27, 1907. Serial. 1st part. No. 83899 B.

Sudbury District.

The Ore Deposits and Geology of the Sudbury District. Hiram W. Hixon. Describes the region and the nickel-copper deposits. Discussion. 5000 w. Jour Can Min Inst—1906. No. 83815 N.

GOLD AND SILVER.

Cobalt.

The Cobalt, Ontario, Camp. From the 1906 report of the Ontario Bureau of Mines. An account of the development and prospecting is given in the present number. 1200 w. Min Rept—April 4, 1907. Serial. 1st part. No. 83522.

The Geology of the Cobalt District. C. R. Van Hise. Believes the ore deposits to have been produced by two concentrations. A study of this district. 1800 w. Can Min Jour—April 1, 1907. No. 83510.

The Bonanza Silver Mines of Cobalt, Ontario. W. Spencer Hutchinson. An illustrated account of the discovery, exploration, and the character of the veins, which are small but rich. 1200 w. Eng & Min Jour—April 27, 1907. No. 83967.

Smelting Cobalt Ores. Hiram W. Hixon. Read before the Can. Min. Inst. Suggests a system of smelting these ores, with the object of inducing the smelting in Canada. 1000 w. Min Wld—March 30, 1907. No. 83379.

Colombia.

The Eocene Gold-Bearing Gravels of Colombia. Francis C. Nicholas. Describes the placer deposits of great wealth which have yielded millions, studying the geological conditions. 2000 w. Min Wld—April 20, 1907. No. 83845.

Colorado.

The Old Hundred Mine and Mill. Illustrates and describes methods of mining huge ore bodies located upon precipitous slopes, and the modern mill and power plant. An illustration of the possibilities of the aerial tramway. 6000 w. Mines & Min—April, 1907. No. 83396 C.

Cyaniding.

Cyaniding Plant for Treating Guanajuato Ores. Carlos W. VanLaw. Illustrated description of plant for treating silver ores. Pulp is transported from the mill to the tanks by a pipe line a mile long. 1200 w. Eng & Min Jour—April 6, 1907. No. 83515.

Cyanide Practice at the Reliance Mill. Douglas Lay. The Hendryx process, agitation, settling and decantation, treating 50 tons of ore per day. Flow sheet. 1200 w. Eng & Min Jour—April 20, 1907. No. 83843.

Last Drainings. H. A. White. A discussion of the possibilities of increased extraction of gold in the South African field. 2700 w. Jour Chem, Met & Min Soc of S Africa—Feb., 1907. No. 83-543 E.

Electrolysis of Gold from Cyanide Solutions. Douglas Lay. Describes the method of recovery used at the Reliance mill, at Nelson, B. C., when complete precipitation was obtained by a solution temperature of 70° F. 2500 w. Eng & Min Jour—April 27, 1907. No. 83969.

Dredge.

The Gold-Dredge as a Machine. Discusses the defects of these dredges and the causes of breakdowns and interruption of work. 4500 w. Engr, Lond—April 12, 1907. No. 83883 A.

Hydraulic Mining.

The Government and Hydraulic Mining in California. William W. Harts. An account of the methods of solving the débris problem. Ills. 2000 w. Min Wld—April 6, 1907. No. 83524.

Mexico.

Old Mexican Workings and Some Remarks on Sampling. T. A. Rickard. Illustrates and describes the workings at the Peregrina mine, near Guanajuato, and describes sampling methods. 3000 w. Min & Sci Pr—April 6, 1907. No. 83569.

The Mines of the Altar District, Sonora. John S. Alexander. Map and description of this district, which contains rich placers and ledges. Silver and copper are also mined. 1000 w. Eng & Min Jour—April 6, 1907. No. 83516.

The Parral District, Mexico. F. Lynwood Garrison. An illustrated account of the present condition of this famous silver mining district in the State of Chihuahua. 1800 w. Min & Sci Pr—March 23, 1907. No. 83346.

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Nevada.

Mining in the Wonder District, Nevada. Edward R. Zalinski. A report of progress since the first claim was located in April, 1906. The chief value is silver, with from one-fifth to one-eighth in gold. Ills. 1500 w. Eng & Min Jour—April 20, 1907. No. 83844.

The Geology of Goldfield, Nevada. Frederick Leslie Ransome. Abstracted from Bul. U. S. Geol. Surv. Map and description. 3300 w. Min & Sci Pr—April 6, 1907. No. 83570.

The Mines of the Fairview District, Nevada. Edward R. Zalinski. Illustrates and describes a new silver-gold camp in Churchill County, where the chief difficulties are lack of water and a long haul to the railroad. 3300 w. Eng & Min Jour—April 13, 1907. No. 83712.

Nova Scotia.

Gold Mining in Nova Scotia. George W. Stuart. Reviews the causes of the present unsatisfactory condition of gold mining in this province. 1600 w. Can Min Jour—April 1, 1907. No. 83512.

Ore Treatment.

Notes on the Occurrence and Treatment of an Auriferous Ore Containing Insoluble Arsenides. J. K. Wilson. A report of experimental investigations of ores of this class. 3500 w. Jour Chem, Met & Min Soc of S Africa—Feb., 1907. No. 83544 E.

Placers.

Examination of Placer Ground. Regis Chauvenet. Remarks on the importance of a careful testing of the ground in placer mining, and a discussion of the pan as a means of testing are given in the present article. 1800 w. Min Rept—April 4, 1907. Serial. 1st part. No. 83523.

Reduction.

Primitive Mexican Crushing and Dressing Plant. Frank H. Probert. Illustrated description of simple appliances devised centuries ago and still in use in the mountains of Chihuahua. 1200 w. Eng & Min Jour—April 6, 1907. No. 83517.

Slimes.

The Tavener Process of Gold Slimes. L. A. E. Swinney. Notes on the smelting of zinc-gold slimes, representing the actual smelting of a "clean-up" from start to finish of a mine on the Rand. Ills. 2000 w. Eng & Min Jour—March 30, 1907. No. 83354.

Stamp Mills.

More Notes on Stamp Mill Practice. Courtenay de Kalb. Opinions concerning screens, foundations, stamp duty, mortar liners, shoes and dies, amalgamation, etc. 3000 w. Can Min Inst—1906. No. 83805 N.

Tests.

Cyanide Tests on Temiskaming Ores. John J. Robertson. Prize paper. A report of tests made and the conclusions. 1800 w. Jour Can Min Inst—1906. No. 83824 N.

Transvaal.

Politics and the Transvaal Mining Industry. Edgar P. Rathbone. An explanation of present conditions and the outlook for mining. 1600 w. Min & Sci Pr—March 30, 1907. No. 83444.

Yukon.

Recent Developments in Mining in the Southern Yukon. D. D. Cairnes. Explains the conditions under which mining must be conducted, and the general characteristics of this district, describing claims seen, and deposits. 1600 w. Can Min Jour—April 15, 1907. Serial. 1st part. No. 83798.

Note on Windy Arm Silver Bearing Veins. R. G. McConnell. Brief description of a mineral area of promise in the Yukon Territory. The geology, veins and mining development. 1500 w. Jour Can Min Inst—1906. No. 83802 N.

IRON AND STEEL.

Blast Furnaces.

The Effect of Moisture in the Atmosphere Upon the Economical Working of Blast Furnaces. Horace Allen. A discussion of the economical results from drying the blast. 1800 w. Mech Engr—March 23, 1907. No. 83412 A.

The Luermann Cinder Notch. Fritz W. Luermann. Describes disturbances in the working of a blast-furnace, and explains the advantages of the Luermann cinder notch. Ills. 1200 w. Ir Age—April 18, 1907. No. 83756.

The Republic Iron & Steel Co.'s New Furnaces. Illustrates and describes in detail the new Haselton furnace plant at Youngstown, O. 2500 w. Ir Trd Rev—April 18, 1907. No. 83791.

Chrome.

Notes on the Production and Uses of Canadian Chrome. W. H. Edwards. Information concerning the chrome iron found in Quebec, the method of mining and treating the ore, the uses, etc. 1000 w. Jour Can Min Inst—1906. No. 83800 N.

Compound Steel.

Compound Steel—A Modern Steel Plant Proposition. Peter Eyermann. Describes a new process for manufacturing steel, stating its advantages. Ills. 3500 w. Elec-Chem & Met Ind—April, 1907. No. 83539 C.

Corrosion.

The Corrosion of Acid and Basic Steel. Alexander G. Fraser. Synopsis of a paper read before the Iron & Steel Inst. Gives the results of some experiments to determine the relative rates of corrosion. Ills. 1600 w. Ir Age—April 18, 1907. No. 83755.

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Electro-Metallurgy.

Some Laboratory Experiments in Making Steel Directly from Iron Ores with the Electric Furnace. J. W. Evans. Illustrates and describes the furnaces used, the methods and results. Discussion. 2500 w. Jour Can Min Inst—1906. No. 83811 N.

Grondal Process.

Magnetic Separation of Iron Ores by the Gröndal Process. P. McN. Bennie. Read before the Can. Min. Inst. (Slightly abridged.) An illustrated detailed description of this concentrating process. 3800 w. Elec-Chem & Met Ind—April, 1907. No. 83540 C.

Iron Ores.

The Supplies and Reserves of Iron Ores. John Birkinbine. Considers the features which demand attention in determining the probable exhaustion of supplies of minerals, and reviews information available concerning the deposits, discussing improvements in methods which have increased the production. Concludes there is no cause for present anxiety. 5000 w. Can Min Jour—April 15, 1907. No. 83797.

Iron Works.

The Barakar Iron Works of the Bengal Iron and Steel Company. From a paper read before the Min. & Geol. Inst. of India. Describes this plant. 1500 w. Ir & Coal Trds Rev—April 5, 1907. No. 83752 A.

Taganrog Iron Works (Das Hüttenwerk der Metallurgischen Gesellschaft zu Taganrog). L. Fortunato. Description of a large establishment in Russia. Diagram. Serial. 7 parts. 17600 w. Oesterr Zeitschr f Berg und Hüttenwesen—Jan. 5, 12, 19 and 26, Feb. 2, 9 and 16, 1907. No. 83612 each D.

Lake Superior.

The Geology of the Cuyuna Iron Range, Minnesota. C. K. Leith. Describes this district of the Lake Superior region. 2500 w. Ec Geol—March, 1907. No. 83342 D.

Geology of the Ely Trough Iron-Ore Deposits. Clarence E. Abbott. Abstract of a paper read before the Lake Superior Min. Inst. Describes these orebodies at Ely, Minnesota, as replacement deposits inclosed in a greenstone trough under a cap of jaspilite. Ills. 4000 w. Eng & Min Jour—March 30, 1907. No. 83353.

Metallography.

The Microstructure of Steel (Das Kleingefüge des Stahles). H. von Jüptner. Illus. Serial. 1st instalment. 1900 w. Oesterr Zeitschr f Berg und Hüttenwesen—March 30, 1907. No. 83661 D.

Nickel Determination.

The Rapid Determination of Nickel in Steel. Dr. George T. Dougherty. Describes a new method which has a claimed capacity considerably above the standard ether method. 2200 w. Ir Age—April 25, 1907. No. 83913.

Prospecting.

Prospecting for Iron Ore in the Tarbrook Iron District, Annapolis County, Nova Scotia. W. F. C. Parsons. Brief description of the territory, deposits, and development. 1000 w. Jour Can Min Inst—1906. No. 83799 N.

Quebec.

Mining Possibilities in the Province of Quebec. Fritz Cirkel. Deals principally with the development of the magnetic iron resources. 2500 w. Can Min Jour—April 1, 1907. No. 83513.

Salisbury Iron.

The Iron Ores of the Salisbury District of Connecticut, New York and Massachusetts. William Herbert Hobbs. Gives information in regard to the history, geology, distribution and mines of these limonite deposits, discussing their origin. 6000 w. Ec Geol—March, 1907. No. 83343 D.

Steel Works.

The First Electrically Driven Reversing Mill. Illustrates and describes the characteristics of this mill in Austrian Silesia, and the electrical apparatus, and discusses the operating curves. 2800 w. Ir Age—April 25, 1907. No. 83912.

The Gadsden Plant of the Southern Steel Company. Plan, sections, and description of a new plant in Alabama. 2500 w. Ir Age—April 11, 1907. No. 83558.

MINING.

Aerial Tramway.

An Aerial Tramway, Seven Miles in Length (Transporteur Aérien de 35 Kilomètres). Illustrated description of the construction and operation of a long aerial tramway for the transport of ore between Chilecito and Upulungos, Argentine Republic. Ill. 3000 w. Génie Civil—March 23, 1907. No. 83693 D.

Black Sands.

Black Sands of New Zealand, the Pacific, and Tierra del Fuego. C. C. Longridge. An account of the auriferous sands of various sea beaches and the methods of treatment. 3500 w. Min Jour—April 20, 1907. No. 83999 A.

Boreholes.

The Deflection of Boreholes in Diamond Drilling on the Rand. A. Zboril. Discusses the cause of the deflection and means of reducing it. Ills. 3000 w. Jour S African Assn of Engrs—March, 1907. No. 83984 F.

Concentration.

Roasting for Magnetic Concentration of Zinc Ores. Frank H. Trego. A com-

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parison of work of a cylindrical furnace commonly used in southwestern Wisconsin with that of a new circular table roaster. 2500 w. Eng & Min Jour—March 30, 1907. No. 83355.

Drills.

Prospecting Drills. Wallace Dickson. Description and information in regard to drills used with description of an ordinary day's work for a runner or helper. 3000 w. Jour Can Min Inst—1906. No. 83823 N.

Hammer Rock Drills, Particularly those made by Flottmann & Co. (Ueber Hammer-Gesteinbohrmaschinen, insbesondere diejenige von H. Flottmann & Co.) Herr Herbst. Description of Flottmann pneumatic drills. Illus. 2400 w. Glückauf—Feb. 9, 1907. No. 83625 D.

Electrical Winding.

Effects of Acceleration on Winding Torques. George Ness. An account of a test of the Tarbrax electric winding plant showing a variation from 15 to 45 kw. in power taken and 48¼ per cent. efficiency. 1800 w. Eng & Min Jour—March 30, 1907. No. 83356.

Mexico.

Mining and General Progress in Mexico. Manuel Diaz Barriga. Gives information showing the importance of mining in Mexico. 1400 w. Min Jour—March 23, 1907. No. 83422 A.

Peculiar Formations of the Mexican Arid Region. Robert T. Hill. Illustrated description of peculiar formations in desert regions. 4500 w. Eng & Min Jour—April 6, 1907. No. 83519.

Mine Inspection.

The Mine Inspection Service of Pennsylvania. An account of its growth, present organization, and the requirements of the law. 4000 w. Mines & Min—April, 1907. No. 83400 C.

Missouri.

Minerals in Missouri. E. R. Buckley. Information in regard to the minerals of value found in this state and their development. Zinc, lead, and coal are the most valuable. 2000 w. Min Wld—March 30, 1907. Serial. 1st part. No. 83381.

Natural Gas.

Natural Gas Wells and Spring of White River. Arthur Lakes. Illustrated description of the only place in Colorado where natural gas occurs in large volume. 800 w. Min Wld—March 30, 1907. No. 83380.

New Zealand.

The Mineral Resources of New Zealand. James Williams. Second prize essay on the present condition and future prospects of the mineral resources of New Zealand, and the best means of fostering their development. Ills. 35000 w. N Z Mines Rec—Feb. 16, 1907. No. 83863 B.

Ore Milling.

Ore Milling in the Slocan, British Columbia. Philip Argall. From the report of the Zinc Commission of British Columbia. Gives suggestions where the present practice might be improved to save greater values. 2500 w. Mines & Min—April, 1907. No. 83399 C.

Props.

The Use of Steel Props and Girders in Mines. James Ashworth. Information in regard to the styles of props, and the cost of steel as compared with wooden girders in England. 1200 w. Mines & Min—April, 1907. No. 83402 C.

Quarrying.

Slate-Quarrying and Dressing. Edgar J. Scaife. Illustrates and describes the methods employed in Wales in quarrying slate for the purpose of conversion into roofing slates. 1800 w. Builder—April 13, 1907. No. 83864 A.

Safety Catches.

Safety Catches and Safety Brakes. K. Schweder. Outlines the main principles of various catches, and gives a detailed description of a carbonic acid safety brake designed by the writer. Ills. 3500 w. Jour S African Assn of Engrs—March, 1907. No. 83983 F.

Shaft Sinking.

Cement Method of Sinking Shafts in Wet Ground (Einiges über das Zementierverfahren beim Abteufen und Ausbau von Schächten in Wasserreichem Gebirge). Julius Divis. Illus. Serial. 2 parts. 5700 w. Oesterr Zeitschr f Berg und Hüttenwesen—Jan. 19 and 26, 1907. No. 83613 each D.

Siberia.

Siberian Mining Labor. C. W. Purington. Information concerning the classes from which mining laborers come in various parts of Siberia and Russia. Does not think the Russian laborers a very comfortable class to get along with. 1500 w. Min Jour—April 6, 1907. No. 83741 A.

A Brief Sketch of the Lena District, Siberia. C. W. Purington. Map and description of the physical features, geology, and gold-bearing gravels. 2500 w. Min Jour—April 20, 1907. No. 83998 A.

South Africa.

Mining Conditions in South Africa. J. B. Pitchford. A description of present conditions and the methods which make possible a production of $10,000,000 of gold per month from ore giving $8.50 per ton. 1500 w. Min Wld—April 6, 1907. Serial. 1st part. No. 83525.

Winding Engines.

A Comparison of Steam and Electric Winding Engines. Gives the conclusions from a paper by Prof. A. Wallichs, in the

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Zeit. des Ver. Deut. Ing. Ills. 1700 w. Engr, Lond—April 5, 1907. No. 83748 A.

Recent Improvements in the Construction of Steam Hoisting Engines (Neuere Erfolge im Bau von Dampffördermaschinen). Ad. Wallichs. Mine hoisting engines described. Illus. Serial. Parts 1 and 2. 2000 w. Oesterr Zeitschr f Berg und Hüttenwesen—March 23 and 30, 1907. No. 83659 each D.

Criticism of Safety Appliances for Steam Hoisting Engines (Zur Kritik neuerer Sicherheitsapparate an Dampffördermaschinen). Herr Hoffmann. Description of safety stops applied to mine hoists, etc. Illus. 5600 w. Glückauf—Feb. 16, 1907. No. 83626 D.

MISCELLANY.

Barytes.

The Barytes Industry of the South. Edward K. Judd. Illustrates a plant in Knoxville, Tenn., for treating barytes, showing that it need not be expensive. 1800 w. Eng & Min Jour—April 20, 1907. No. 83841.

British Columbia.

On Surveys in New Westminster District and Texada Island. O. E. LeRoy. A summary report of the geological survey, the deposits, etc. Ills. 1800 w. B C Min Rec—Feb., 1907. No. 83784 B.

Canada.

On the Advisability of the Establishment of a Federal Department of Mines. H. Mortimer Lamb. Reviews the history of the geological survey of Canada in its relation to the mining industry, and outlines work to be accomplished. 7500 w. Jour Can Min Inst—1906. No. 83807 N.

A Canadian Department of Mines or Geological Survey. J. B. Tyrrell. Considers the duties and uses of such a department. General discussion. 2200 w. Jour Can Min Inst—1906. No. 83808 N.

On the Need of a Topographical Survey of the Dominion of Canada, Particularly with Reference to the Development of the Economic Resources of the Dominion. Frank D. Adams. Shows the need of such a map for the proper development of the country, and outlines the features and advantages of such maps. 5000 w. Jour Can Min Inst—1906. No. 83806 N.

Carbon.

Carbon; a Remarkable Mineral. I. C. Yawger. Interesting information in regard to this mineral, found only in a small section of Brazil. Ills. 3000 w. Min Wld—March 30, 1907. No. 83378.

Chile.

See Industrial Economy.

Diamonds.

The Occurrence of Diamonds in the Drift of Some of the Northern States. Dr. Robert Bell. Discusses the question of the area from which the diamonds have been derived. 1500 w. Jour Can Min Inst—1906. No. 83810 N.

Explosion.

Explosions in the Roburite Works at Witten (Die Explosionen in der Roburitfabrik bei Witten). Dr. Klocke. Diagrams. 2800 w. Glückauf—March 23, 1907. No. 83664 D.

Finance.

Requirements of Modern Mining. J. R. Finlay. Discusses some of the requirements involved in a successful mining business, and the questions to be met in the near future. 2000 w. Min & Sci Pr—April 20, 1907. No. 83964.

Graphic Formulae.

The Use of Graphic Formulae in Metallurgical Calculations. David H. Browne. Read before the Can. Min. Inst. Outlines methods whereby the records of one particular ore may be tabulated and reduced to graphic formulae. 3000 w. Elec-Chem & Met Ind—May, 1907. No. 83978 C.

Igneous Rocks.

A Simple Classification of Igneous Rocks. Scott Turner. Gives a table designed to help in the identification of eruptive rocks, with notes. 1400 w. Min & Sci Pr—March 30, 1907. No. 83443.

Labor.

Mining Labor in Australia. W. J. Loring. Considers the Australian workman superior to any known by the writer in other parts of the world, and gives an account of his characteristics and conditions. 1600 w. Min & Sci Pr—April 20, 1907. No. 83965.

Laboratory Furnaces.

Laboratory Crucible and Muffle Furnaces. George T. Holloway. Describes furnaces that have stood the test of six years' uninterrupted use. Ills. 3000 w. Inst of Min and Met, Bull 31—April 11, 1907. No. 84014 N.

Lead.

Lead Deposits in Northern Kentucky. R. B. Brinsmade. An account of workable lead veins within 50 miles of Cincinnati, O. 1200 w. Eng & Min Jour—April 6, 1907. No. 83518.

Lead Smelting.

A New Matte Separator. R. R. Hedley. Describes a device successfully used in the lead smelting works at Nelson, invented by Henry Harris. Ills. 1200 w. Jour Can Min Inst—1906. No. 83804 N.

Manganese.

Determination of Manganese in the Presence of Tungsten (Ueber die Manganbestimmung bei Anwesenheite von Wolfram). G. von Knorre. 2200 w. Stahl und Eisen—March 13, 1907. No. 83623 D.

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Metallurgy.

Physical Chemistry in Metallurgy. Dr. Alex. Findlay. Abstract of a paper read before the Iron & Steel Inst. Shows how physical chemistry explains the laws of the relationships existing between the different structures and their formation. 2200 w. Min Rept—April 11, 1907. No. 83723.

Mexico.

Geology of Sierra Almoloya, Mexico. Robert Thomas Hill. Illustrated description of this range, its geologic structure and mineralization. The ores are valuable for their size and variety, which consist of about equal values in gold, silver, copper, lead, with zinc, iron, and manganese lime flux. 3000 w. Min Wld—April 27, 1907. No. 83975.

Molybdenite.

Molybdenite Deposit in Australia. John Plummer. Describes these deposits and the mining and preparation. Ills. 1600 w. Min Wld—March 30, 1907. No. 83382.

Nickel.

Genetic Relations of Nickel-Copper Ores, with Special Reference to the Deposits at St. Stephen, N. B., and Sohland, Germany. Charles W. Dixon. Briefly reviews the geology of nickel ores in general and discusses the deposits named. Ills. 8200 w. Jour Can Min Inst—1906. No. 83816 N.

On the Nickel Deposits of Webster, Western North Carolina. Alfred E. Barlow. The character and composition of the ore, the geological relations, mode of occurrence, and origin are considered. Ills. 8200 w. Jour Can Min Inst—1906. No. 83819 N.

The Atik-Okan Nickeliferous Pyrrhotite Deposits and Their Origin. F. Hille. A description of the physical features, geology, etc. Ills. 6000 w. Jour Can Min Inst—1906. No. 83818 N.

Oklahoma.

Lead and Zinc Mining. W. R. Crane. A description of the occurrences of ore and methods of mining and milling in the Quapaw district, Oklahoma. 2500 w. Mines and Min—May, 1907. No. 84063 C.

Ore Deposits.

The Relation of Ore-Deposition to Physical Conditions. Waldemar Lindgren. Aims to trace, in a general way, the relations of certain well-known mineral groupings to the physical conditions which there is reason to assume existed during their genesis. 6000 w. Ec Geol—March, 1907. No. 83340 D.

Some Relations of Paleogeography to Ore Deposition in the Mississippi Valley. H. Foster Bain. A study of the relations of sedimentation to ore deposition, especially in connection with the lead and zinc deposits. 5500 w. Ec Geol—March, 1907. No. 83341 D.

Petroleum.

Petroleum in Illinois. H. Foster Bain. Describes the characteristics of these oilfields in southeastern Illinois. 1200 w. Eng & Min Jour—April 20, 1907. No. 83842.

South Platte Valley.

Topographic Development of Chalk Bluffs and Pawnee Buttes. Junius Henderson. A study of the surface features of South Platte Valley and the relation to underlying deposits of coal, lime, building stone, brick and fire clay, oil and water. Ills. 3000 w. Ores & Metals—April 20, 1907. No. 83856.

Tin.

Cornish Methods of Crushing and Ore Dressing. Edward Walker. A discussion of old and new methods in the dressing of tin ore, and the apparatus used. Ills. 3000 w. Eng & Min Jour—April 13, 1907. No. 83715.

Recent Progress in the Metallurgy of Tin, with Regard to Electrochemistry in 1906 (Fortschritte und Neuerungen in Der Metallurgie Des Zinns, Spoziell in Elektrochemischer Hinsicht im Jahre 1906). H. Mennicke. Review of recent metallurgical processes for the treatment of tin. Serial. 1st part. 2400 w. Elektrochemische Zeitschrift—March, 1907. No. 83669 G.

Yukon.

Yukon Mining Laws. J. B. Tyrrell. Presents some of the main provisions of the laws which have been in force for the past eight years, pointing out their advantages and disadvantages in the working of gold-bearing gravel deposits. 3500 w. Jour Can Min Inst—1906. No 83809 N.

Zinc.

A Study of the Ferrocyanide Method for the Determination of Zinc. W. H. Seamon, in *West. Chem. & Met.* A study of the conditions influencing the determination. 2500 w. Min Rept—April 11, 1907. No. 83722.

Lucky Jim Mine, Slocan District. An expert's description of one of the largest zinc mines in British Columbia. 3800 w. B. C. Min Rec—Feb., 1907. No. 83786 B.

The Valuation of Roasted Blend with Regard to Its Sulphur Content. V. Hassreidter-Trooz. Abstracted from *Zeit. f. angew Chemie.* Gives table showing results of analyses of ten different blendes roasted in six plants, discussing the results. 800 w. Eng & Min Jour—April 13, 1907. No. 83714.

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RAILWAY ENGINEERING

CONDUCTING TRANSPORTATION.

Accidents.

British Practice in Railroad Accident Inquiries and Railroad Inspection. H. A. Yorke. A statement of British practice with review of the Railroad Acts and legislation, and editorial. 3300 w. R R Gaz—April 19, 1907. No. 83828.

The Recent Accident on the New York Central and Hudson River Railroad. An illustrated account of the Woodlawn accident, discussing its cause. 3700 w. Engng—April 12, 1907. No. 83880 A.

Progress.

Progress in Transportation. G. M. Basford. Extracts from an address before the Tech. Pub. Assn., New York. Remarks on the influence of the railroad on civilization, and especially on the development of the United States. 1200 w. Am Engr & R R Jour—April, 1907. No. 83491 C.

Telpherage.

Branch Railways by the Telpherage System. Illustrates and describes a typical telpherage line, explaining its advantages, cheapness of construction and operation, and its solution of the problem of overcrowded freight lines. 1500 w. Sci Am—April 13, 1907. No. 83577.

Train Lighting.

See Electrical Engineering, Lighting.

Train Tests.

Apparatus for Testing the Handling of Passenger Trains. Frank McManamy. Illustrates and describes a machine for automatically recording all the details of a trip, explaining the charts and the working of the machine. 2800 w. Pro St Louis Ry Club—March 8, 1907. No. 83590.

Trans-Siberia.

Trans-Siberian Ry. Service. From a report by Consul-General Thomas Sammons, of Newchwang, Manchuria, based upon recent personal observations. Information concerning the accommodations and facilities of interest to travelers. 2300 w. Ry & Engng Rev—March 30, 1907. No. 83375.

MOTIVE POWER AND EQUIPMENT.

Brakes.

Defects of New Brake Equipment. G. W. Kiehm. Gives suggestions for cleaning and testing feed valves, and related subjects. 1000 w. Ry & Loc Engng—April, 1907. No. 83531 C.

Cars.

All-Steel Box Cars. A. M. Waitt. Gives a warning against the extensive adoption of these cars for all kinds of service in all climates. Calls attention to the enormous heat accumulated in the sides of steel cars in mid-summer, and the injury to many classes of freight carried, and to cattle, and to other disadvantages. 1300 w. Ry Age—April 12, 1907. No. 83726.

All-Steel Box Cars. Illustrates and describes two cars for the Union Pacific R. R., recently finished at the Omaha shops. 1100 w. Am Engr & R R Jour—April, 1907. No. 83486 C.

All-Steel Postal Car. An illustrated description of a car for the Pennsylvania Railroad, said to be the first absolutely non-combustible postal car ever built. 600 w. Am Engr & R R Jour—April, 1907. No. 83490 C.

All-Steel Pullman Sleeping Car. Illustrated description of a car to be exhibited at Jamestown, which is as near all-metal construction as is now practicable. 600 w. R R Gaz—April 19, 1907. No. 83826.

Electrification.

The Electrification of Steam Railways from the Operating Point of View. As regards ease of operation and continuity of service considers the third-rail system superior to the single-phase overhead system. 2500 w. Elect'n, Lond—March 29, 1907. No. 83548 A.

The Overhead Construction on the Electric Division of the New York, New Haven & Hartford R. R. Foster Hannaford. Brief illustrated description of the trolley wires, the cables from which they are suspended and the bridges which suspend the cables. 1600 w. Yale Sci M—April, 1907. No. 83918 C.

Electric Traction on Railways. Philip Dawson. Considers the various causes which have led to the electrification of railways in the present article. 2500 w. Elect'n, Lond—April 19, 1907. Serial. 1st part. No. 83993 A.

Engine Repairs.

Dispatching Board for Engine Repairs. C. J. Morrison. Describes a board used in the Topeka shops to aid the general foreman in keeping an account of the condition of the work. 600 w. Am Engr & R R Jour—April, 1907. No. 83487 C.

Instruction Car.

New Air Brake Instruction Car. Brief illustrated description of a recently completed car for the C. B. & Q. Ry. representing the latest development. 800 w. Ry Mas Mech—April, 1907. No. 83470.

We supply copies of these articles. See page 526.

Locomotives.

Modern Locomotive Engineering in Germany. Charles S. Lake. Gives particulars of the design and proportions of locomotives built in accordance with German ideas at the present time, embracing locomotives for home and foreign service, and for varying classes of traffic. Ills. 1500 w. Mech Engr—March 30, 1907. Serial. 1st part. No. 83546 A.

The Design of Recent English Locomotives. Particulars and illustrations of some of the new engines recently placed in English service. 3500 w. Eng News—April 18, 1907. No. 83890.

Mogul Locomotives for the Isthmian Canal Commission. Gives the principal features in the design of these engines, with illustrations. 300 w. Ry & Engng Rev—April 13, 1907. No. 83729.

Heavy Vandalia Moguls. Illustration, with description of heavy 2-6-0 engines. 600 w. Ry & Loc Engng—April, 1907. No. 83534 C.

Narrow-Gauge Eight-Wheel Duplex Locomotive. Illustrated description of an engine built for a railway of 2 ft. 5½ in. gauge, in the Island of Euboea, designed for large hauling power and suited to sharp curves. 500 w. Engng—April 12, 1907. No. 83881 A.

New Locomotives for the Natural Railway of Mexico. Illustrates and describes Pacific type locomotives recently completed. They comprise 3 simple engines with Richardson slide valve, 1 with Allfree-Hubbell valves and cylinders, and 1 Cole four-cylinder balanced compound engine with Walschaert valve gear. 900 w. Ry Age—April 5, 1907. No. 83536.

New Locomotives for the Cerro de Pasco Ry. Illustrates and describes two engines of the Mikado type and one of the Mogul type built for freight service on a standard-gage road in Peru. 500 w. Ry & Engng Rev—April 6, 1907. No. 83537.

New Type of Great Western Express Engine: An Evolution. Charles Rous-Marten. Introductory remarks on the work of Mr. G. J. Churchward, describing some of his designs, and giving a description of the new type, of which ten are under construction. 3500 w. Engr, Lond—March 29, 1907. Serial. 1st part. No. 83451 A.

Simple Decapod Locomotive. Illustrated description of heavy simple engines for pushing service on the B., R. & P. railroad. 600 w. Am Engr & R R Jour—April, 1907. No. 83488 C.

Tank Locomotive for the Nevada Northern. A heavy tank engine, intended for service between the mines and smelting plant of the Nevada Consolidated Copper Co., is illustrated and described. 400 w. Ry Age—April 12, 1907. No. 83727.

Smith & Perkins, and Their Locomotives. C. H. Caruthers. Drawings, illustrations, descriptions, and general information concerning engines built in Alexandria, Va., between the years 1851-1858. 3500 w. R R Gaz—April 19, 1907. No. 83829.

New Locomotive for the Italian State Railways (Nuove Locomotive delle Ferrovie Italiane di Stato). Description of this four-cylinder compound locomotive. Ill. 2000 w. Il Monit Tech—March 30, 1907. No. 83679 D.

Ten-Wheel Locomotive for the St. Louis and San Francisco. Illustrated description of locomotives fitted with the Walschaert valve motion, worked out so that the motion is carried in a straight line, without offset, from the eccentric crank to the valve stem. 400 w. R R Gaz—April 26, 1907. No. 83923.

Locomotives at the Milan 1906 Exposition (Die Lokomotiven auf der Internationalen Ausstellung in Mailand 1906). K. Sanzin. Description of various types of engines shown, with tables of dimensions, weight, etc. Illus. Continuation of serial; unfinished. 7000 w. Zeitschr d Oesterr Ing u Arch Vereins—March 8, 22 and 29, 1907. No. 83653 each D.

Motor Cars.

Recent Steam Motor Cars in Great Britain. Charles S. Lake. Cars used on the Taff Vale Railway, and the Lancashire and Yorkshire Railway are illustrated and described. 900 w. Am Engr & R R Jour—April, 1907. No. 83489 C.

The Steam Motor Car: Its Value in Interurban Service. W. G. Wagenhals. Read before the Iowa St. & Int. Ry. Assn. Describes a car recently built, explaining the service for which it is intended. 2000 w. St Ry Jour—April 20, 1907. No. 83830.

Valve Gears.

Walschaerts vs Stephenson Gears. W. W. Wood. A discussion of the two valve motions, submitting five propositions bearing on the subject. 2000 w. Ry & Loc Engng—April, 1907. No. 83529 C.

Adjusting Stephenson Valve Gear. James Kennedy. Describes methods of careful adjustment. 2000 w. Ry & Loc Engng—April, 1907. No. 83535 C.

Water Purification.

The Purification of Water (Note sur l'Epuration des Eaux). M. H. Boileau. Methods employed to purify boiler-feed water containing sulphur and magnesium chloride by the Phosphate and Railway Company of Gafsa, Tunis (la Compagnie des Phosphates et du Chemin de Fer de Gafsa, Tunisie). Ill. 8000 w. Rev Gen d Chem d Fer—March, 1907. No. 83684 G.

We supply copies of these articles. See page 526.

NEW PROJECTS.

Florida.

The Key West Extension of the Florida East Coast Railway. Illustrated description of a remarkable piece of railroad building now in progress from Miami to Key West, Fla. 1500 w. Ry Age—April 19, 1907. No. 83846.

Building the Florida East Coast Extension to Key West. F. E. Spooner. An illustrated article giving information in regard to this interesting work and the labor conditions. 2000 w. R R Gaz—April 26, 1907. No. 83926.

Mexican Central.

The Pacific Extension of the Mexican Central Railway. Describes an important piece of railway construction which will open a new port and give connection between the Pacific and Gulf. 3500 w. Eng News—April 4, 1907. No. 83451.

New Haven.

The Cut Improvements of the New Haven R. R. at New Haven. Outlines the improvements in progress and illustrates and describes interesting features of the work. 2500 w. Eng Rec—April 13, 1907. No. 83706.

New South Wales.

The Great Zig-Zag on the New South Wales Railways. An illustrated description of a scheme to cost £300,000, which will give a new route where traffic can be more easily carried. 500 w. Engr, Lond—March 22, 1907. No. 83428 A.

PERMANENT WAY AND BUILDINGS.

Block System.

Government Report on the Block System. Part of the report sent to Congress Feb. 23, 1907, considering the history, cost, safety, deficiencies, etc. 6500 w. R R Gaz—April 5, 1907. Serial. 1st part. No. 83454.

Coaling Station.

The Coaling Station of the Pennsylvania Railroad at Morrisville. Describes a structure of steel and reinforced concrete. 1000 w. Eng Rec—April 27, 1907. No. 83942.

Construction.

Railway Construction in Difficult Country. Information from report of Henry Deane concerning the construction and operation of railways in mountainous country. 3000 w. Ry & Engng Rev—April 20, 1907. No. 83849.

Costs.

Railway Maintenance of Way. Walter K. Hardt. Discusses the elements that influence the costs of keeping the property up to a proper standard, and the lack of significance of figures as a basis of comparison. 3800 w. Jour of Accountancy—April, 1907. No. 83587 C.

Curves.

The Strain on Curve Spikes. An Abstract of the report of Prof. George F. Swain of computations made in a study of this subject. 2500 w. St Ry Jour—March 30, 1907. No. 83362.

Four-Tracking.

Changing from Double to Quadruple Track (Transformation en Quadruple Voie de la Double Voie de Paris à Creil par Chantilly). M. Rossignol. Illustrated description of the work of tearing down the old masonry overhead crossings without interfering with traffic. Ill. 2200 w. Rev Gen d Chem d Fer—March, 1907. No. 83690 G.

Location.

Economics of Railway Location. Abstract of a report presented at meeting of the Am. Ry. Engng. & Main.-of-Way Assn., with editorial. 4000 w. R R Gaz—April 19, 1907. No. 83827.

Maintenance.

Maintenance of Way. F. O. Dufour. Discusses the permanent way from an economical standpoint, pointing out defects and suggesting remedies. 5500 w. Pro St Louis Ry Club—April 12, 1907. No. 83959.

Rails.

Continuous Rails for Uniform Track Structure. Editorial discussion of the difficulties and conditions, and the appliances to meet the requirements. 1800 w. R R Gaz—April 12, 1907. No. 83573.

Roadbed.

Some Roadbed and Track Standards, N. Y. C. & H. R. R. R. Illustrated detailed description of the construction of the four-track lines. 1400 w. Ry & Engng Rev—April 20, 1907. No. 83848.

Shan Tun.

Construction of the Shan Tun Railway (Vom Bau der Shantung-Eisenbahn). Hermann Meyer. General description of location, permanent way and bridges of a new railway traversing the province of Shan Tun in eastern China. Illus. Serial. 1st part. 2100 w. Deutsche Bauzeitung—Feb. 16, 1907. No. 83634 D.

Shops.

The New Locomotive Repair Shops of the Lackawanna Railway at Scranton, Pa. Illustrates and describes the large modern plant for heavy and light repairs of locomotives which will soon supersede the present shops. 3500 w. Ry Age—April 12, 1907. No. 83725.

Signaling.

Railroad Management and Safety Devices. J. C. Irwin. Deals with the main features of signaling practice at the present time, giving a detailed description of an important installation. 5500 w. Jour Fr Inst—April, 1907. No. 83759 D.

Unsettled Questions in Railway Sig-

We supply copies of these articles. See page 526.

naling. W. H. Elliott. Abstract of a paper read before the New England Ry. Club. A discussion of questions closely connected with the operation of block-signal systems. 5000 w. Eng News—April 18, 1907. No. 83891.

Spikes.

Holding Force of Railroad Spikes in Wooden Ties. A report to the U. S. Dept. of Agriculture by W. Kendrick Hatt. Reports tests made to compare the relative holding force of common, channeled, and screw spikes when driven into railroad ties of both hard and soft woods. 1000 w. R R Gaz—April 26, 1907. No. 83924.

Splugen.

The Splügen Railway (Splügenbahn). Description of a new railway and tunnel in the Engadine, Switzerland. Illus. 2300 w. Schweizerische Bauzeitung—March 2, 1907. No. 83633 B.

Stations.

Rearrangement of the Leipzig Stations of the Saxon State Railway. E. Toller. Trans. from the *Organ für die Fert des Eisenbahn.* Explains the conditions that made the work necessary and the changes proposed. 3500 w. Bul Int Ry Cong—March, 1907. No. 83598 E.

New Passenger Station of the Lackawanna at Scranton, Pa. Illustrated description of a fine structure about to be erected. 600 w. Ry Age—April 19, 1907. No. 83847.

Tunnel in Watergraasmeer Sorting Station in Amsterdam (Tunnel im Rangierbahnhofe der Holländischen Eisenbahn—Gesellschaft in Watergraasmeer bei Amsterdam). H. Masereeuw. Mathematical treatment of the design to be executed in concrete. 2300 w. Serial. 1st part. Beton und Eisen—March, 1907. No. 83647 F.

Switzerland.

New Permanent Way of the Swiss Railways (Der Neue Oberbau der Schweizer Bundesbahnen). Fritz Hromatka. Description and specifications for roadbed, rails and steel ties. Illus. 2300 w. Oesterr Woch f d Oeffentlichen Baudienst—March 23, 1907. No. 83645 D.

Terminals.

Chicago & Western Indiana Engine Terminal. Illustrated description of this new engine terminal, made necessary by the work of track elevation at Chicago. 3300 w. Ry & Engng Rev—March 30, 1907. No. 83374.

Ties.

Treatment of Railroad Ties and the Materials Available for this Purpose in New Jersey, New York, and Pennsylvania. L. Bush. A statement of the difficulties of the tie problem, discussing the financial aspect of the situation. 6000 w. Eng Rec—April 20, 1907. No. 83832.

TRAFFIC.

Freight.

Losses and Damages to Freight. Robert L. Calkins. A discussion of freight claims by the freight claim agent of the New York Central. 2000 w. Ry Age—March 29, 1907. No. 83376.

Freight Cars.

The Interchange Use of Freight Cars in North America. W. F. Allen. Reviews the methods of accounting used and the regulations and agreements suggested. 4500 w. Bul Int Ry Cong—March, 1907. No. 83597 E.

The Freight Car Situation. Report of the Committee on Car Efficiency of the American Railway Association. Information gathered and a discussion of what can be done to improve the situation. 3000 w. R R Gaz—April 26, 1907. No. 83925.

Improvements.

Double-Tracking and Yard Improvements to Facilitate Freight Traffic on Railways. Editorial discussion of the freight congestion problem, quoting from recent papers and giving the conclusions reached. 4500 w. Eng News—April 4, 1907. No. 83453.

Rating.

Tonnage Rating. F. W. Thomas. From a paper before the Trav. Engrs. Assn., 1906. Discusses the factors affecting the tonnage hauled. 2500 w. Am Engr & R R Jour—April, 1907. No. 83492 C.

MISCELLANY.

Abandoned Railway.

A Railway in Ruins. An illustrated account of the Shrewsbury, Potteries and North Wales Railway. 2000 w. Engr, Lond—April 5, 1907. No. 83750 A.

Governmental Control.

The Purchase of the Western Railway of France. An editorial review of the conditions governing the relations between the railways and the State in France. 2800 w. Engng—March 15, 1907. No. 83468 A.

Railway Problems.

J. B. Thayer on Railway Problems. Abstract of an address at Buffalo, N. Y. Examines the reasons advanced for the so-called "regulation of railroads." 2000 w. Ry Age—April 26, 1907. No. 83973.

Resistance.

A Study of Train Resistance. J. G. Van Zandt. A study of the conditions of speed and trains that affect the resistance. 4000 w. Wis Engr—April, 1907. No. 83859 D.

Water-Softening.

Railway Water-Softening. An abstract of the more important sections of the report of the Committee on Water Service, presented at the convention of the Am. Ry. Engng. & Main.-of-Way Assn. 2700 w. Eng Rec—April 20, 1907. No. 83838.

We supply copies of these articles. See page 526.

STREET AND ELECTRIC RAILWAYS

Electric Locomotive.

Three-Phase Locomotive with Three Ranges of Speed for the Italian State Railways. Bela Valatin. Illustrated detailed description. 2000 w. St Ry Jour—April 6, 1907. No. 83476.

Electric Traction.

Development in Heavy Electric Traction. A series of short papers by prominent men in the electrical and mechanical world on some phases of heavy electric traction. 15000 w. Pro N Y R R Club—March 25, 1907. No. 83754.

Electric Operation of Main Line Railways from an Agricultural and Strategic Standpoint (Der elektrische Betrieb auf Vollbahnen vom wirtschaftlichen und strategischen Standpunkte). Eugen Cserhati. Discussion of the effect of the operation of the Simplon tunnel by electricity as a strategic feature between Switzerland and Italy. Illus. 4200 w. Zeitschr d Oesterr Ing und Arch Vereines—Feb. 15, 1907. No. 83616 D.

Exposition.

Transportation at the Jamestown Exposition. E. C. Hathaway. Explains the plans for handling the large crowds expected. Ills. 900 w. St Ry Jour—April 6, 1907. No. 83478.

Electric Railway Exhibits at Milan, 1906 (Die elektrischen Bahnen auf der Ausstellung in Mailand 1906). A. Zweiling. Illus. Conclusion of serial. 1800 w. Zeitschr d Ver Deutscher Ingenieure—March 16, 1907. No. 83627 D.

Freight.

Freight-Hauling by Electric Lines. P. P. Crafts. Read before the Iowa St. & Int. Ry. Assn. A discussion of matters relating to interurban freight traffic, showing that it can be made successful. 4000 w. St Ry Jour—April 20, 1907. No. 83831.

Interurban.

Some Construction and Operating Features of the Alton, Granite & St. Louis Railway. Illustrated description of a system having a number of overhead railway crossings, and many viaducts. 1600 w. St Ry Jour—March 30, 1907. No. 83358.

The Marion Bluffton & Eastern Railway. An important interurban line, recently completed in Indiana, is illustrated and described. 1200 w. Elec Ry Rev—April 6, 1907. No. 83527.

The Norwich & Westerly Railway. Illustrated detailed description of this high-speed interurban electric railway between Norwich, Conn., and Westerly, R. I. 2500 w. St Ry Jour—April 13, 1907. No. 83703.

The Pittsburg & Butler Street Railway. Illustrated detailed description of a line between the cities named, passing through attractive suburbs of Pittsburg and important oil and coal centers. 4000 w. Elec Ry Rev—April 27, 1907. No. 83974.

Lausanne.

Lausanne Tramways (Les tramways Lausannois). Aug. Wohnlich. Description of the construction and the operative features of the street railways of a modern Swiss city. Illus. Serial. 1st and 2d instalments. 7200 w. Bull Technique de la Suisse Romande—Jan. 10 and Jan. 25, 1907. No. 83606 each D.

Motor Cars.

New 14-Ton Motor Cars, Denver City Tramway. Illustrated description of cars having an especially low weight per unit of seating capacity. 1200 w. Elec Ry Rev—April 6, 1907. No. 83526.

Power Station.

New Power Plant of the Central Pennsylvania Traction Company at Harrisburg, Pa. Illustrates and describes interesting features. 2200 w. St Ry Jour—April 27, 1907. No. 83972.

Rails.

Rail Corrugation. Joseph A. Panton. Gives details of the method of investigation employed by the writer, and the results that formed the basis of his theory that the trouble is due to defects in the rolling-stock. Ills. 5000 w. Inst of Elec Engrs—March 21, 1907. No. 83556 N.

Rapid Transit.

A Continuous Variable-Speed System of Rapid Transit. Illustrated description of a system operated by a continuous screw without motors or transmission and with no risk of collision. 1700 w. Sci Am—April 6, 1907. No. 83458.

Scotland.

Dumbarton Electric Tramways. Illustrated detailed description of these electric lines and their equipment. 2200 w. Tram & Ry Wld—April 4, 1907. No. 83775 B.

Shops.

Car House and Shops at Knoxville, Tenn. Illustrated detailed description of the new buildings and their equipment. 1500 w. Elec Ry Rev—April 13, 1907. No. 83721.

Simplon Tunnel.

The Electric Installations for the Operation and Lighting of the Simplon Tunnel (Les Installations Electriques pour l'Exploitation et l'Eclairage dans le grand

We supply copies of these articles. See page 526.

Tunnel du Simplon). E. Rod. The first instalment describes the cables for telegraph, telephone, lighting, signal systems, their construction, laying, etc. Ill. Serial. 1st part. 2500 w. Bull Tech d l Suisse Rom—March 25, 1907. No. 83698 D.

Electric Traction in the Simplon Railway Tunnel. J. B. van Brussel. An illustrated description of this successful installation on the three-phase system. 2500 w. Engineering Magazine—May, 1907. No. 83937 B.

Single-Phase.

Lecture on Single Phase Traction. Abstract of a lecture by W. S. Murray, before the Elec. Engng. Soc. of Columbia Univ., giving information concerning single-phase traction, particularly the method employed by the N. Y., N. H. & H. R. R. in substituting electric for steam locomotives. 1500 w. St Ry Jour—March 30, 1907. No. 83361.

Standardization.

A Claim Agent's View of Standardization. Edward O'Callaghan. An address on the standardization of street railway equipment. 1700 w. St Ry Jour—April 6, 1907. No. 83477.

Subways.

Pittsburgh Subways. E. K. Morse. Explains present conditions in this city and the pressing need of better transit facilities, giving reasons against elevated roads and in favor of underground railways, and discusses the construction, motive power, etc. Also considers subways generally. Ills. and general discussion. 12000 w. Pro Engrs' Soc of W Penn—March, 1907. No. 83702 D.

The Lexington Avenue Subway, New York. Plans and description of this new line about to be constructed. 1500 w. Elec Ry Rev—April 13, 1907. No. 83720.

Subway Station.

Preliminary Construction for the Manhattan Subway Station at Williamsburg Bridge. Illustrates and describes preliminary work for the construction of a station providing for an eight-loop terminal for surface cars and a 620-ft. two-track terminal for elevated trains. 1200 w. Eng Rec—April 27, 1907. No. 83948.

Switzerland.

The Electric Railways and Tramways of Switzerland. W. A. Müller. Translated from *Elektrische Bahnen und Betriebe*. A summary gives particulars of each line, and then considers the results of operating the electric railways and their peculiarities. Map. 7800 w. Bul Int Ry Cong—Feb., 1907. No. 83292 E.

Tracks.

Track Bonding. Thomas B. McMath. Read before the Cent. Elec. Ry. Assn. Brief notes on early methods of bonding, with a description of work in Indianapolis. Short discussion. 2500 w. Elec Ry Rev—March 30, 1907. No. 83363.

Train Control.

A New Multiple Unit System of Train Control. Illustrated description of a new method in use on the Liverpool-Southport electric line. The main feature is the use of solenoid contractors with series, as distinct from shunt, magnets. 2000 w. Elect'n, Lond—April 19, 1907. Serial. 1st part. No. 83997 A.

Turn-Table.

Single Ending Cars with a Novel Turn-Table as Recently Installed by the Public Service Corporation at Hoboken, N. J. Martin Schreiber. Illustrated detailed description of this table and its operation. 1000 w. St Ry Jour—March 23, 1907. No. 83235.

Ventilation.

The Ventilation of Tube Railways. Abstract of a paper by M. C. Birault, read before the Soc. des Ing. Civ. de France. On the Ventilation of Railway Tunnels and Underground Railways. Concludes that very active ventilation is necessary, giving suggestions for securing it. 900 w. Engr, Lond—March 8, 1907. No. 83122 A.

The Ventilation of Railway Tunnels and of City Subways (La Ventilation des Tunnels de Chemins de Fer et des Métropolitains Souterrains). M. C. Birault. An elaborate discussion of the subject with descriptions of methods employed in many European tunnels and subways. Ill. 55000 w. Mem d l Soc d Ing Civ d France—Jan., 1907. No. 83689 G.

The Ventilation and Cooling of the Simplon Tunnel (La Ventilation et la Réfrigération du Tunnel du Simplon). E. Mermier. The first part of the serial describes the methods used to ventilate other similarly-situated tunnels and the first projects for the Simplon. Ill. Serial. 1st part. 2400 w. Bull Tech Suisse Rom—April 10, 1907. No. 83673 D.

Waste Gases.

Waste Gases as a Source of Power for the Operation of Electric Railways. F. E. Junge. A study of the possibilities of utilizing the waste gas energy from iron smelting and coal mining industries for generating electric power. 4000 w. Cassier's Mag—April, 1907. No. 83331 B.

Wheels.

Car Wheels for Interurban and City Service. C. Skinner. Read before the Cent. Elec. Ry. Assn. Brief discussion of wheels for high-speed equipment weighing 40 tons or over per car. Short discussion. 1500 w. Elec Ry Rev—March 30, 1907. No. 83364.

We supply copies of these articles. See page 526.

EXPLANATORY NOTE—THE ENGINEERING INDEX.

We hold ourselves ready to supply—usually by return of post—the full text of every article indexed in the preceding pages, *in the original language*, together with all accompanying illustrations; and our charge in each case is regulated by the cost of a single copy of the journal in which the article is published. The price of each article is indicated by the letter following the number. When no letter appears, the price of the article is 20 cts. The letter A, B, or C denotes a price of 40 cts.; D, of 60 cts.; E, of 80 cts.; F, of $1.00; G, of $1.20; H, of $1.60. When the letter N is used it indicates that copies are not readily attainable, and that particulars as to price will be supplied on application. Certain journals, however, make large extra charges for back numbers. In such cases we may have to increase proportionately the normal charge given in the Index. In ordering, care should be taken to *give the number* of the article desired, not the title alone.

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THE PUBLICATIONS REGULARLY REVIEWED AND INDEXED.

The titles and addresses of the journals regularly reviewed are given here in full, but only abbreviated titles are used in the Index. In the list below, *w* indicates a weekly publication, *b-w*, a bi-weekly, *s-w*, a semi-weekly, *m*, a monthly, *b-m*, a bi-monthly, *t-m*, a tri-monthly, *qr*, a quarterly, *s-q*, semi-quarterly, etc. Other abbreviations used in the index are: Ill—Illustrated: W—Words; Anon—Anonymous.

American Architect. *w.* New York.
Am. Engineer and R. R. Journal. *m.* New York.
American Jl. of Science. *m.* New Haven, U. S. A.
American Machinist. *w.* New York.
Annales des Ponts et Chaussées. *m.* Paris.
Ann. d Soc. Ing. e d Arch. Ital. *w.* Rome.
Architect. *w.* London.
Architectural Record. *m.* New York.
Architectural Review. *s-q.* Boston.
Architect's and Builder's Magazine. *m.* New York.
Australian Mining Standard. *w.* Melbourne.
Autocar. *w.* Coventry, England.
Automobile. *w.* New York.
Automotor Journal. *w.* London.
Beton und Eisen. *qr.* Vienna.
Boiler Maker. *m.* New York.
Brass World. *m.* Bridgeport, Conn.
Brit. Columbia Mining Rec. *m.* Victoria, B. C.
Builder. *w.* London.
Bull. Am. Iron and Steel Asso. *w.* Phila., U. S. A.
Bulletin de la Société d'Encouragement. *m.* Paris.
Bulletin of Dept. of Labor. *b-m.* Washington.
Bull. Soc. Int. d'Electriciens. *m.* Paris.
Bulletin of the Univ. of Wis., Madison, U. S. A.
Bulletin Univ. of Kansas. *b-m.* Lawrence.
Bull. Int. Railway Congress. *m.* Brussels.
California Jour. of Tech. *m.* Berkeley, Cal.
Canadian Architect. *m.* Toronto.
Canadian Electrical News. *m.* Toronto.
Canadian Engineer. *m.* Toronto and Montreal.
Canadian Mining Journal. *b-w.* Toronto.
Cassier's Magazine. *m.* New York and London.
Cement. *b-m.* New York.
Cement Age. *m.* New York.
Central Station. *m.* New York.
Chem. Met. Soc. of S. Africa. *m.* Johannesburg.
Colliery Guardian. *w.* London.
Compressed Air. *m.* New York.
Comptes Rendus de l'Acad. des Sciences. *w.* Paris.
Consular Reports. *m.* Washington.
Deutsche Bauzeitung. *b-w.* Berlin.
Domestic Engineering. *w.* Chicago.

Economic Geology. *m.* So. Bethlehem, Pa.
Eisenbahntechnische Zeitschrift. *b-m.* Berlin.
Electrical Engineer. *w.* London.
Electrical Review. *m.* London.
Electrical Review. *w.* New York.
Electric Journal. *m.* Pittsburg, Pa.
Electric Railway Review. *w.* Chicago.
Electrical World. *w.* New York.
Electrician. *w.* London.
Electricien. *w.* Paris.
Electrochemical and Met. Industry. *m.* N. Y.
Elektrochemische Zeitschrift. *m.* Berlin.
Elektrotechnik u Maschinenbau. *w.* Vienna.
Elektrotechnische Zeitschrift. *w.* Berlin.
Elettricità. *w.* Milan.
Engineer. *w.* London.
Engineer. *s-m.* Chicago.
Engineering. *w.* London.
Engineering-Contracting. *w.* New York.
Engineering and Mining Journal. *w.* New York.
Engineering Magazine. *m.* New York and London.
Engineering News. *w.* New York.
Engineering Record. *w.* New York.
Eng. Soc. of Western Penna. *m.* Pittsburg, U. S. A.
Far Eastern Review. *m.* Manila, P. I.
Fire and Water. *w.* New York.
Foundry. *m.* Cleveland, U. S. A.
Génie Civil. *w.* Paris.
Gesundheits-Ingenieur. *s-m.* München.
Giorn. dei Lav. Pubb. e d Str. Ferr. *w.* Rome.
Glaser's Ann. f Gewerbe & Bauwesen. *s-m.* Berlin.
Heating and Ventilating Mag. *m.* New York.
Ice and Refrigeration. *m.* New York.
Industrial World. *w.* Pittsburg.
Ingenieria. *b-m.* Buenos Ayres.
Ingenieur. *w.* Hague.
Insurance Engineering. *m.* New York.
Int. Marine Engineering. *m.* New York.
Iron Age. *w.* New York.
Iron and Coal Trades Review. *w.* London.
Iron and Steel Trades Journal *w.* London.
Iron Trade Review. *w.* Cleveland, U. S. A.
Jour. of Accountancy. *m.* N. Y.
Journal Asso. Eng. Societies. *m.* Philadelphia.
Journal of Electricity. *m.* San Francisco.
Journal Franklin Institute. *m.* Philadelphia.
Journal Royal Inst. of Brit. Arch. *s-qr.* London.
Jour. Roy. United Service Inst. *m.* London.
Journal of Sanitary Institute. *qr.* London.
Jour. of South African Assn. of Engineers. *m.* Johannesburg, S. A.
Journal of the Society of Arts. *w.* London.
Jour. Transvaal Inst. of Mech. Engrs., Johannesburg, S. A.
Jour. of U. S. Artillery. *b-m.* Fort Monroe, U. S. A.
Jour. W. of Scot. Iron & Steel Inst. *m.* Glasgow.
Journal Western Soc. of Eng. *b-m.* Chicago.
Journal of Worcester Poly. Inst., Worcester, U. S. A.
Locomotive. *m.* Hartford, U. S. A.
Machinery. *m.* New York.
Madrid Cientifico. *t-m.* Madrid.
Manufacturer's Record. *w.* Baltimore.
Marine Review. *w.* Cleveland, U. S. A.
Mem. de la Soc. des Ing. Civils de France. *m.* Paris.
Métallurgie. *w.* Paris.
Minero Mexicano. *w.* City of Mexico.
Mines and Minerals. *m.* Scranton, U. S. A.
Mining and Sci. Press. *w.* San Francisco.
Mining Journal. *w.* London.
Mining Reporter. *w.* Denver, U. S. A.
Mittheilungen des Vereines für die Förderung des Local und Strassenbahnwesens. *m.* Vienna.
Motor Wagon. *w.* Cleveland, U. S. A.
Municipal Engineering. *m.* Indianapolis, U. S. A.
Municipal Journal and Engineer. *w.* New York.
Nature. *w.* London.
Nautical Gazette. *w.* New York.
New Zealand Mines Record. *m.* Wellington.
Oest. Wochenschr. f. d. Oeff. Baudienst. *w.* Vienna.
Oest. Zeitschr. Berg & Hüttenwesen. *w.* Vienna.
Plumber and Decorator. *m.* London.
Popular Science Monthly. *m.* New York.
Power. *m.* New York.
Practical Engineer. *w.* London.
Pro. Am. Soc. Civil Engineers. *m.* New York.
Pro. Canadian Soc. Civ. Engrs. *m.* Montreal.
Proceedings Engineers' Club. *qr.* Philadelphia.
Pro. St. Louis R'way Club. *m.* St. Louis, U. S. A.
Pro. U. S. Naval Inst. *qr.* Annapolis, Md.
Quarry *m.* London.
Queensland Gov. Mining Jour. *m.* Brisbane, Australia.
Railroad Gazette. *w.* New York.
Railway Age. *w.* Chicago.
Railway & Engineering Review. *w.* Chicago.
Railway and Loc. Engng. *m.* New York.
Railway Master Mechanic. *m.* Chicago.
Revista d Obras. Pub. *w.* Madrid.
Review of Reviews. *m.* London & New York.
Revista Tech. Ind. *m.* Barcelona.
Revue de Mécanique. *m.* Paris.
Revue Gén. des Chemins de Fer. *m.* Paris.
Revue Gén. des Sciences. *w.* Paris.
Revue Industrielle. *w.* Paris.
Revue Technique. *b-m.* Paris.
Rivista Gen. d Ferrovie. *w.* Florence.
Rivista Marittima. *m.* Rome.
Schiffbau. *s-m.* Berlin.
Schweizerische Bauzeitung. *w.* Zürich.
Scientific American. *w.* New York.
Scientific Am. Supplement. *w.* New York.
Sibley Jour. of Mech. Eng. *m.* Ithaca, N. Y.
Stahl und Eisen. *s-m.* Düsseldorf.
Stevens Institute Indicator. *qr.* Hoboken, U. S. A.
Street Railway Journal. *w.* New York.
Technograph. *yr.* Urbana, Ill.
Technology Quarterly. *qr.* Boston, U. S. A.
Tijds v h Kljk. Inst. v Ing. *qr.* Hague.
Tramway & Railway World. *m.* London.
Trans. Am. Ins. Electrical Eng. *m.* New York.
Trans. Am. Ins. of Mining Eng. New York.
Trans. Am. Soc. Mech. Engineers. New York.
Trans. Inst. of Engrs. & Shipbuilders in Scotland, Glasgow.
Transport. *w.* London.
Wood Craft. *m.* Cleveland, U. S. A.
Yacht. *w.* Paris.
Zeitschr. f. d. Gesamte Turbinenwesen. *w.* Munich.
Zeitschr. d. Mitteleurop. Motorwagon Ver. *s-m.* Berlin.
Zeitschr. d. Oest. Ing. u. Arch. Ver. *w.* Vienna.
Zeitschr. d. Ver. Deutscher Ing. *w.* Berlin.
Zeitschrift für Elektrochemie. *w.* Halle a S.

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Engineering Index.

The Engineering Index Annual for 1906. Size 9½ by 7 in.; pp. 416. Price, $2. New York and London: THE ENGINEERING MAGAZINE.

This volume represents the continuation of the work originally started by the late Professor J. B. Johnson in the Journal of the Association of Engineering Societies in 1884, and turned over by that association to THE ENGINEERING MAGAZINE at the close of 1895. The previous volumes, published respectively in 1892, 1896, 1901, and 1906, covered with increasing care and thoroughness the field of technical engineering periodical literature, and in the present volume every care has been taken to maintain and advance the standard set by its predecessors.

The publication of the quinquennial volumes of the Index was a matter of great labor and expense for which there was no adequate return. It necessitated the entire re-editing of the Index items as they appeared in the pages of THE ENGINEERING MAGAZINE from month to month, a work which required the almost constant attention of a large editorial staff. In view of the limited outlet for the book, this undertaking was not a financial success. Nor was the five-yearly volume entirely satisfactory from the user's point of view. In the rapid increase in technical knowledge and the constant change and development of engineering practice, much of the material indexed was obsolete before the appearance of the book, and, furthermore, searches through the pages of the Magazine between the appearance of one volume and that of the next became a very laborious task. The publication of the Index in annual volumes, therefore, should render it of much greater value to the engineer in placing the information before him while it is still fresh and most likely to be of service.

In the present volume the items are printed as they appeared originally in the Magazine and under the same scheme of classification. While the strictly alphabetical arrangement used in former volumes may be preferred by a certain small class of students, it is probable that the system which has given so much satisfaction to the users of the Index as it appears in the Magazine will meet with the full approval of the average consultant of this volume. The work is divided into eight main sections devoted to, respectively, Civil Engineering, Electrical Engineering, Industrial Economy, Marine and Naval Engineering, Mechanical Engineering, Mining and Metallurgy, Railway Engineering, and Street and Electric Railways. Each of these main divisions is subdivided into several smaller sections, under which the catch-words of the various items are arranged in alphabetical order. The whole object of this plan is to collate for each specialist, the entire current literature of his subject and to assemble it in a small space where it may readily be found and completely explored.

Aside from this detail of arrangement, the work is identical in plan and execution with its predecessors. It presents a complete review of the entire technical press of the world for the year 1906. In it are indexed over 7000 articles of permanent value which appeared in over 250 technical journals, in English, French, German, Italian, Spanish and Dutch. Besides the title and the author's name, there are given in each case, the length of the article in words, the name and date of the publication in which it appeared, and a short *résumé*, indicative of the general scope of the article and prepared by a staff of specialists in the various branches of engineering.

The volume is one which will prove invaluable to any engineer. By no other means can the specialist keep in touch with the development of his particular line in all parts of the world, and to the occasional user it points the way to the latest and best information on any desired subject. To the student also it is indispensable in the proper investigation of any special subject or branch of engineering work. In scope, in thoroughness, and in accuracy it is a work of the highest merit, one which no engineer who wishes to keep up with the development of his profession can afford to be without.